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SCIENTIFIC AMERICAN SUPPLEMENT. No. 1734

Entered at the Post Office of New York, N. Y., as Second Class Matter.

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Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII., No. 1734.

NEW YORK. MARCH 27, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

VIEW SHOWING THE BODY OF THE WAGON IN ITS TILTED OR DUMPING POSITION.

VIEW SHOWING THE BODY OF THE DUMP WAGON IN NORMAL POSITION.

AUTOMOBILE TILTING DUMP WAGON FOR THE CITY OF COLOGNE.

AN AUTOMOBILE TILTING DUMP WAGON.

A NEW VEHICLE FOR THE CITY OF COLOGNE.

BY THE GERMAN CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE accompanying photographs represent a tilting van recently built for the city of Cologne by the Stoewer firm of Stettin. The chassis of this van is made of substantial channel steel beams connected by cross beams of the same kind and reinforced with solid sheet-steel angles. The forged axles are very substantial, and are provided in front with a special patented steering system, which has proved highly satisfactory in the case of heavy vans. The wheels are of the artillery type with heavy wood spokes and felloes and steel hubs of ample dimensions. They are fitted with readily exchangeable bronze boxes, which retain lubricant material for a long time.

The 32-horse-power motor is a perfectly balanced four-cycle engine, the cylinders of which are cast in pairs. Its normal speed is about 900 r. p. m. The motor, owing to its remarkable elasticity and well-adjusted carbureter, is readily adapted to higher or lower speeds. The ignition is of the high-tension magneto type, the magneto being driven by completely incased gears and running at the speed of the engine crankshaft.

Like the magneto, the pump is located on the left-hand side of the motor, and is likewise actuated by interchangeable and entirely inclosed gears. It sends the cooled water from the bottom of the radiator into the jacket of each pair of cylinders between the exhaust valves, after which the water flows round the valves, the upper cylinder walls, the explosion chamber, and sideways between the admission valves of each pair of cylinders, whence it goes out at the top and back into the radiator. The latter is mounted in front of the motor, and is made up of thin undulating strips. A fan located immediately behind the radiator greatly increases its efficiency, and is assisted by another fan mounted on the flywheel of the motor. Special attention has been paid to the design of the lubricating apparatus.

The gasoline tank is placed below the driver's seat, and is provided with special safety devices.

An ordinary leather-lined cone clutch is used for transmitting the power from the motor to the transmission gear. The dimensions of this cone are such as to completely transmit the power of the motor, even in the case of the highest strains, while at the same time allowing of a smooth and gradual starting. The pressure of the spring acting on this cone is taken by a substantial thrust bearing, and the length of the levers connecting to the pedal is such as to reduce to a minimum the effort required for throwing out the clutch. The spokes of the clutch are in the shape of fan blades, so that they assist in cooling.

The gears of the transmission are made of chrome-nickel steel, and are very strong and durable. All the shafts run in first-class ball bearings inclosed in entirely dust-proof cases, so as to be subjected to as little wear and tear as possible. The gears are designed according to a special design which is said to reduce the noise to a minimum. The differential gears are of forged steel and, in addition to the supporting ball bearings, they are provided on both sides with very substantial thrust bearings for taking the thrust of the worm driving gears and also the lateral thrust of the two driving sprockets. Like all the shafts concerned, the ball bearings are relieved of any lateral pressure. Four forward speeds and one reverse are provided, all of which are controlled by a single lever.

The interchangeable brakes of very substantial design are located, one on each side of the differential gear respectively, and are operated by two pedals located beside the clutch pedal.

Chain drive has been retained, the sprockets being given specially suitable dimensions, so as to reduce the noise of operation and increase their life. The rear-wheel brakes, controlled by a long and substantial hand lever to the right of the driver's seat, are of the contracting band type. Particular attention has been paid to the design of the steering. The throttle lever is located in the steering wheel; and as the motor, owing to its power and elasticity, can be run at varying speeds, this location of it allows the speed of the car to be readily adapted to the actual conditions of the road.

The van carries an effective load of five tons.

ALCOHOL MOTORS.

SOME CALORIFIC FACTS.

THE tables of Landolt and Börnstein give the pressures of vapors of alcohol and of water at various temperatures, from 10 deg. to 50 deg. C. (50 deg. to 122 deg. F.). Prof. Eugene Meyer adds the amounts which 1 kilogramme of air can take up at the temperatures named. They are reckoned for pressures (*a*) of 735.5 millimeters (28.957 inches) of mercury, i. e., one kilogramme per square centimeter (14.2234 pounds per square inch), and (*b*) of 662 millimeters (26.06 inches) of mercury or 0.9 kilogramme per square centimeter (12.8 pounds per square inch) to show that with lower pressure—that is, greater suction—more watery vapor can be taken up by the air, and the alcohol can vaporize at a lower temperature.

In the following all the metric units have been changed to British, by no means because the latter are preferable, but because many American readers cannot think in metric units.

The air, when drawn into the motor, contains a certain proportion of water, which we will assume so great that the air, if drawn in at 15 deg. C. (59 deg. F.) is already saturated with watery vapor, corresponding to 11 grammes of water to one kilogramme of air, or 1.1 per cent saturation. In this case the temperature must be so high that with mixture No. 1, 22 grammes (2.2 per cent), or with mixture No. 2, 29 grammes (2.9 per cent) of water are contained in the air, in addition to the alcohol therein. Calculation shows that under a pressure of 735.5 millimeters (28.957 inches) of mercury, with mixture No. 1 a temperature of 25 deg. C. (77 deg. F.) and with mixture No. 2, 30 deg. C. (86 deg. F.) is necessary. These temperatures are exceptionally low; but if only the alcohol is to be vaporized, and not the water, they must be still lower. For according to the table there are already at 15 deg. C. (59 deg. F.), 75 grammes (1,157 grains) of alcohol vaporized, while in the case of mixture No. 2 it is only necessary to vaporize 69 grammes (1,065 grains) so that at 15 deg. C. some water would remain.

When, therefore, the various walls that the mixture touches are not cooler than 25 deg. to 30 deg. C. (77 deg. to 86 deg. F.), one need not fear condensation of vapor on them. But where there is water circulation to effect cooling, the wall temperature is often in all places higher than demanded above. Where there is cooling by evaporation, the wall temperature is even over 100 deg. C. (212 deg. F.). This explains why in alcohol motors during suction there is condensed on the walls no alcohol vapor, which would cause imperfect combustion.

To form vapor, the liquid alcohol fed to the motor must be heated. The evaporation temperatures of alcohol are known. Its total heat units at different temperatures are, according to Regnault, as follows:

Temperatures.	Metric Heat Units or Kilogramme-Calories.	Temperatures.	British Heat Units.
0 deg. C.	206.5	32 deg. F.	928.4
20 deg. C.	252.0	68 deg. F.	1000.0
50 deg. C.	304.0	122 deg. F.	1047.6
100 deg. C.	307.3	212 deg. F.	1060.0

The specific heat of liquid alcohol being about 0.6 that of water, we must add to one kilogramme of alcohol at 20 deg. C. (68 deg. F.) about 240 metric heat units (naturally the same number of British heat units per pound) to evaporate it at about 25 deg. to 30 deg. C. (77 deg. to 86 deg. F.). To boil water at these temperatures takes about 600 heat units. There are, then, necessary to evaporate mixture No. 1 for every 1 pound or kilogramme of air $0.69 \times 240 + 0.011 \times 600 = 23.2$ heat units.

As the calorific effect of 86.6 per cent alcohol is about 5,500 heat units, there will be set free by the perfect combustion of mixture No. 1, $5{,}500 \times 0.080 = 440$ heat units.

For mixture No. 2 the corresponding value is $5{,}500 \times 0.131 = 720$ heat units. The heat necessary for evaporation will therefore be about 5.5 per cent of that contained in the combustible, and can therefore be very easily delivered either by the exhaust gases or by the walls and the cooling water.

The necessary heat to evaporate the alcohol can be obtained by warming the air before mixing it therewith. As the specific heat of air under constant pressure is 0.2375, we have in this case with mixture No. 1, to warm the air $23.2 \div 0.2375 + 25 = 125$ deg. C. (257 deg. F.); and with mixture No. 2, to 190 deg. C. (374 deg. F.).

If, on the contrary, we warm the mixture itself, so that the alcohol comes in contact with hot surfaces, these surfaces must be so much higher in temperature than 25 deg. to 30 deg. C. (77 deg. to 86 deg. F.), in order that the heat may be given rapidly to the mixture. To heat the air, or it and alcohol together, higher than necessary to keep the mixture from containing any liquid when it enters the cylinders—say 25 deg. to 30 deg. C. (77 deg. to 86 deg. F.)—is unnecessary, and even harmful; as the hotter the mixture the earlier the impulses will take place, and the less the degree of compression that we can use with due regard to quiet running.

As, however, heat will be added to the mixture in any case by the cylinder walls, valve surfaces, etc., the temperature, if above 25 deg. to 30 deg. C. (77 deg. to 86 deg. F.) will rise still further in the interior of the motor during the intake. To use high compression, it is therefore desirable to deliver a part of this mixture unvaporized into the cylinder, and let it vaporize upon the walls, so that this extra heat shall cause no rise of temperature, but evaporation. There is only the danger that the mixture will be unhomogeneous, and that for example in those parts where a portion of alcohol vaporizes, there will be too rich a mixture, and too little air therefor.

In view of these considerations we can judge of the value of the two diametrically opposite practices of motor-builders—for instance, that without special pre-warming, and that in which there is very considerable pre-warming. In the former the outer wall of the intake pipe, in the place where the alcohol vapor is injected into the air, is cold, when the motor is running under load, and is always covered with condensed moisture. There can be no perfect vaporization at the point of injection. As this point, however, is almost directly over the inlet valve, the passage to the cylinder is very short and so nearly straight, that no excessive amount of liquid alcohol is thrown out of the mixture, and the combustible arrives in the cylinder well mixed with air. As cooling by evaporation is here employed, there the wall is hot enough to evaporate the alcohol fully, and render the mixture practically applicable. The mixture, remaining as cool as possible, can be highly compressed.

As the high degree of pre-warming in the second case, causing good diffusion and homogeneous mixture, favorably influences the alcohol consumption, one can see why, given the same compression, it has more favorable consumption and lower losses than the non-preheating type. The low compression is purposely given, because the very hot mixture, if compressed more highly, would cause undue shocks. Indeed, even with the low compression here given, this type barks louder than the other. So what is gained by high pre-heating is lost by the low compression possible; and in fact, the non-warming type is, because of the higher compression, more economical of alcohol than the other, with pre-heating of the mixture. This high pre-heating thins the charge and therefore diminishes the specific duty.

NOTE.—The amount of heat necessary to raise the temperature of one kilogramme of water one deg. C. = 3.96832 "pounds Fahrenheit" or British heat units (also called "pound calorie"). One British heat unit = 0.252 kilogramme calorie.

THE MANUFACTURE OF SMOKELESS POWDER.

FROM THE RAW MATERIAL TO THE FINISHED PRODUCT.

BY DAY ALLEN WILLEY.

NOT so long ago the battleship "Iena," one of the finest of the French navy, was lying in the Toulon drydock, being overhauled for service. Officers and crew aboard were as unconscious of danger as the men of the "Maine" before the death blow came to them. There was an explosion—not very heavy—then followed another that shook the ship from stem to stern. A volcano of flame, as the spectators put it, burst from her interior. More and more explosions followed, so rapidly that they could not be counted. The "Iena" had been attacked from within. Luckily, a shell from another vessel knocked away the gate of the drydock, and the water rushing in partly filled her hull and extinguished the raging fires, but not before over a hundred men had perished and the craft was a wreck—destroyed by her own missiles.

What caused the catastrophe? Smokeless powder.

The destruction of the "Maine" was a mystery, as Capt. Sigsbee and his officers admit. The French government at first endeavored to veil the Toulon tragedy in mystery; but it was unsuccessful, and it is now generally admitted that the disaster was caused by a chemical change in the powder so simple that any child could perform it with his school apparatus—a change which may occur wherever the same kind of ammunition which was aboard the "Iena" is kept in the magazines—the ammunition we call smokeless powder.

What is smokeless powder? Principally guncotton mixed with two or three chemicals. What is guncotton? Just cotton soaked in acid.

Most of the stuff composing it is grown in the fields of the South, and the schoolboy chemist can make the acids; but it is the way in which he prepares his ingredients and mixes them together that shows the skill of the powder maker. Here is something that must be made with the utmost care if it is to be used with safety.

A trivial error may change it from an explosive that can be handled and kept without harm into a fearful instrument of death and disaster—more dangerous because the element it may contain is unseen and unknown, and may not show its power until years after the powder has been pressed into its strips and cylinders, and stored in the ship. Out of a million or so of these cylinders perhaps a few hundred are not pure. There comes a day when they begin to give off fumes. Should the gunner or storekeeper enter the magazine, he will quickly know something is wrong, for they are fumes of nitrous gas, pungent and disagreeable. But the powder room may not be opened for weeks—only the temperature noted by the thermometer at its entrance—so the gas rapidly increases its rate of generation, and a greater and greater volume arises. The impure powder changes from the hard shiny pieces of gutta percha it resembles into a pasty yellow mass. If the chemist is called to investigate, he says that the nasty-smelling gas is due to the formation of oxide of nitrogen, while in the yellow paste formic acid and acetic acid are now at work. In short, the powder is no longer powder. It has decomposed.

If the gas has any crack or crevice through which it can escape in sufficient quantities, ship and sailors may keep afloat; but suppose the magazine is airtight or nearly so. It is astonishing how much gas even one cylinder of powder will generate; and if the chamber is nearly full of ammunition, very little of the decomposing stuff is sufficient to fill the space with the fumes. As they grow thicker, they quickly raise the temperature. Here is where the danger point is set; for if the air becomes heated above a certain degree, it means combustion of the yellow paste, which will ignite much more quickly than the powder itself. The fact is that the gas, if confined in sufficient volume, will so heat the air that the paste will ignite.

What happens then is what happened to the "Iena," what happened to the "Mikasa" as she went under the waters at Sasebo with the banner of the sunflower flying and her hundreds of seamen crying "Banzai" as the sea closed above their heads.

If we look into the making of guncotton, we realize how much truth lies in this theory. Yes, it consists simply of fiber which we strip from the cotton boll of the southland, soaked in acid; but to do this and do it right is not the simple thing it seems. If you should enter one of the few factories where it is made, you would see an imposing variety of machinery used for nothing else. The same kind of waste with which the engineer wipes his valves and levers—the refuse cotton which is thought too dirty or poor to be spun or woven—is now used mainly for the explosive. First it is treated to a bath of hot water and caustic soda, in which it stays eight hours, to be then dumped into another vat of clear cold water, after the other liquid has been drained from it. This cleansing ought to remove the grease and dirt which may be in it; but it is subsequently picked to shreds by hand and examined for any bits of sand, gravel, or other foreign substances. Then it is washed a third time; being whirled round and round for eight minutes while a jet of cold water is played upon it. The whirling is done in what is called a centrifugal washer, which is driven by steam power at the rate of 1,400 revolutions a minute. This partly dries the cotton, just as one can dry his handkerchief in a minute or so by letting it flutter in the breeze. But the cotton has to be almost absolutely dry if the acid is to do its work; so it is laid on racks in a heating chamber where the temperature is 187 degrees, and stays there from three to five days. The cotton, however, usually becomes so tangled and twisted during its baths, that even this exposure does not dry all of it; so it is run through a picking machine, which combs the fiber straight and separates the tangles. It is then once more exposed to the heat for at least eight hours.

Thus far the cotton is the pure staple and nothing else. Now begins the change from a harmless lint into one of war's most powerful instruments. Bits of it weighing about a pound are taken and dipped in troughs filled with acid, about one-fourth of the mixture being sulphuric acid and the balance nitric acid. After each dip, the workman squeezes and kneads the wad of cotton to mix the acids with it. The dipping continues about ten minutes, when the stuff is "digested"—not as we digest our food, but left in a pot of hot water, where it steeps, so to speak, and the acid more thoroughly assimilates with the fiber. Following a bath of cool water, it is passed through a machine that squeezes out the water as a clothes wringer aids in drying the laundry.

This, however, is only the beginning of a series of washings and dryings, the reason for which will be made clearer by what follows. A vat called the immersion tub is partly filled with caustic soda and hot water. Into this the nitro-cellulose, as the chemist calls it, is placed in handfuls, so that it will be as thoroughly saturated as possible. For eight hours it is boiled, to next be placed in clear cold water, which rinses it for the same length of time. Now it is turned over to the pulping machine, where revolving knives cut the fiber into such small pieces that it becomes pulp in appearance. Again it is washed in a vat of water, where the particles of pulp are kept in motion by revolving feathers. After being mixed in this way for two days it is put in the "stuffing chest," where it receives another stirring. It is then taken to the first molding press. Here the water it contains is partially squeezed out; but the creation of the guncotton is not complete until it is further dried by pressure under the enormous pressure of 6,000 pounds to each square inch of its surface.

Why all these washings and dryings and sortings? Because the cotton, before it receives its acid bath, must be entirely free from any foreign substance if the wonderful chemical change it undergoes is to be successfully and safely accomplished. And the acid must impregnate every particle of the fiber. Look at a bit of cotton under a powerful microscope, and you may note that each tiny filament, or hair if you will, is twisted. Its surface is not smooth. The acid must not merely cover each hair, but must permeate it—become a part of the new substance which is created by this union. So it is that the cotton is not only cleaned but combed, and is soaked a handful or so at a time, to be squeezed and soaked again and again.

Now, to make the smokeless powder that goes into the magazines of our warships and our forts, the makers simply dissolve the guncotton and dry the paste that is left until it looks like sheets of shellac or caramels before they are cut into morsels. It is no more powder than is macaroni; although the long slim tubes into which the "powder" is molded before being sliced into flakes and compressed into gun charges feel hard and smooth like macaroni. It is now of a dark brown color. These flakes are no more powerful than the guncotton, but are more convenient to handle, and take up less space. Most of the American powder, however, is made by putting the cotton into a combination of ethyl alcohol and ethylic ether, to which are added some barium nitrate, a little potassium, and a trace of calcium carbide. In this solution the cotton literally melts away, and the paste takes its place. But the creation of the paste is a work that no man sees; for after the cotton and the solution are placed in the "kneading machine," and the machine started, every one leaves the building. The kneading is done by a set of revolving paddles that keep the mixture thoroughly stirred up while it is in the kneading vat; but the vat is covered with a heavy iron jacket to check the force of explosions, for though few accidents of the kind have so far occurred, no one knows when one may happen. During this process, which lasts about four hours, the paste is partly dried. It is then forced between steam-heated rollers; but the transparent shellac-like sheets are completely freed from moisture in a drying room, where they are exposed to a high temperature. Then they can be cut by machinery to be used for gun charges.

Suppose merely one of these many processes which create the smokeless powder is omitted or carried out too hastily. Suppose the cotton is not thoroughly freed from impurities or the acids are not strong enough. The chemist says that the mixture will not be stable. What does he mean by that? Simply that it is liable to decompose, especially in a warm climate. It is not merely unsafe, but highly dangerous. The nitric acid and sulphuric acid must be very strong and pure. Their test of strength is their specific gravity. Our grade of smokeless powder is supposed to be made from guncotton which has been soaked in nitric acid whose gravity is at least 1.49 and sulphuric acid of a gravity of 1.835. Much of the acid made in the chemical plants, however, is weaker than this. If the acid is even five per cent weaker, it is not fit to be used; so say the few government experts who inspect the making of this ammunition. Here is something else they say: If even a trace of the acid is left in the guncotton, which has not impregnated it and is still in the acid form, it will, to use the proper scientific term, cause progressive decomposition. Just an atom of this acid which may have escaped the many washings and steepings and wringings is like a yellow-fever microbe in the human body. It may so leaven the compound that the change of a half degree in temperature will cause it to take fire by spontaneous combustion.

NATURAL AND ARTIFICIAL ASPHALT.

NATURAL asphalt can be distinguished without difficulty from substitutes made of coal tar pitch, but it has hitherto been impossible to separate natural asphalt and petroleum residues, because the two substances are very similar in composition. Marcusson and Eickmann have recently succeeded in distinguishing between natural and petroleum asphalt by means of their oily constituents. Natural asphalt contains from 1.4 to 31 per cent of oil, which becomes completely liquid at 64 deg. F., at which temperature the larger quantity of oil, from 26 to 58 per cent, contained in petroleum asphalt still retains the consistency of soft lard.

A still better means of discrimination is afforded by the respective quantities of paraffin contained in the two substances. Natural asphalt, on distillation, yields little or no paraffin, while the distillate obtained from petroleum asphalt consists chiefly of paraffin.

The following process is recommended for the determination of the proportion of petroleum products in asphalt. The specimen is distilled, and the distillate is dissolved in benzol, precipitated with petroleum ether and further purified with suphuric acid and soda lye. The proportion of oil is then determined, and from this a conclusion is drawn in regard to the presence and quantity of petroleum products. The result may be confirmed by distilling the oil and determining the percentage of paraffin in the distillate by means of alcohol and ether, by Holde's method. If the paraffin amounts to more than 2 per cent of the weight of the oil, before distillation, an admixture of petroleum asphalt may be regarded as probable.

Cement for Vessels to Hold Acids.—Damaged porcelain, glass and other vessels that are used to contain acids, can best be cemented with a mixture consisting of 1 part each of asbestos and fine floor sand and 3 to 4 parts of soda water glass (30 deg. Bé.). The mass can be molded, hardens in the air and is fire-resistant. After being exposed to the action of the acids in these vessels, the cement becomes water-resistant, although before it would be softened by water.

WIRELESS TELEPHONY.—III.

ITS HISTORY AND PRESENT STATUS.

BY REGINALD FESSENDEN.

Concluded from Supplement No. 1733, page 182

5. *Receiver Connections.*—Where the wireless telephone is operated by first talking into the transmitter and then throwing a switch and listening, the usual wireless telegraphic connections are used. This has been found in practice to be very inconvenient, however, and several methods have therefore been devised for talking and listening simultaneously, which methods can, of course, also be applied to duplex wireless telegraphy. Among these methods may be mentioned the commutator method† and the balance method.‡

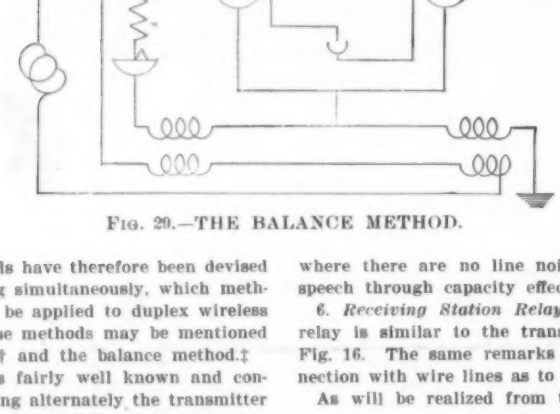


FIG. 29.—THE BALANCE METHOD.

The former method is fairly well known and consists in rapidly connecting alternately the transmitter and receiver. The balance method consists in using a phantom aerial as shown in Fig. 29, where *P* is a phantom aerial, the circuit having such capacity inductance and resistance as to balance the radiating antenna. The apparatus is shown in Fig. 29a.

In order entirely to cut out disturbances in the receiver while sending, an interference preventer, *I. P.*, the elements of which are shown in Figs. 29b and 29c is used in the receiving circuit.

It may be here mentioned that balance methods work much better with wireless telephony and telegraphy than with line telephony and telegraphy, for the reason that the radiation resistance of an antenna is absolutely definite and is not affected by the weather, as are line circuits.§ Consequently, the balance can be made very sharp and once made does not need to be altered. Of course, half the energy is lost, but this is a matter of practically no importance, as the cutting down of the strength of a telephonic conversation to one-half is as a rule hardly noticeable, especially where there are no line noises or distortion of the speech through capacity effects.

6. *Receiving Station Relay.*—The receiving station relay is similar to the transmitting relay shown in Fig. 16. The same remarks apply to its use in connection with wire lines as to the transmitting relay.

As will be realized from the above, the operation of a wireless telephone system is very simple. The operator merely throws his switch to the position for telephoning and talks into an ordinary transmitter and listens in an ordinary telephone receiver. When the duplex method is used, as is always advisable, the conversation proceeds exactly as over an ordinary telephone line. Fig. 30 shows a phonograph transmitting music and speech wirelessly. Fig. 31 shows talking by relays from a local circuit.

I believe I am correct in saying that the transmission by wireless telephone is considerably more distinct than by wire line and that the fine inflections of the voice are brought out much better. This, I presume, is due to the fact that there is no electrostatic capacity to distort the speech, as in the case of wire lines, though I think the effect is also partly due to the absence of telephone induction coils with iron cores. Possibly some of the gentlemen present have witnessed the operation of the wireless telephone transmission between Brant Rock and Plymouth and between Brant Rock and Brooklyn. If so I think they will bear me out in saying that the transmission was clearer than over wire lines.

As a rule, there is absolute silence in the wireless telephone receiver except when talking is going on, though of course the usual noises may be heard if persons are walking across the room, etc. This makes listening in less of a strain than when talking over wire line. Even during severe atmospheric disturbances the talking is not interfered with to any noticeable extent, provided of course that an interference preventer is used.

A comparative test was made with talking between Brant Rock and Brooklyn by wireless and by wire telephony. The talking over the wire line was done from a long distance station in Brooklyn. The wireless transmission was considerably the better. The fact that the wire line included in its circuits a cable from New York to Brooklyn was of course a disadvantage, but even allowing for this, practice and theory appear to be in agreement to the effect that transmission by wireless telephony over long distances is better than by wire line.

This method should be of especial value to independent telephone companies, which have their local exchanges, but no long distance lines, especially since no franchises or rights of way are necessary.

FIG. 29A.—APPARATUS OF THE BALANCE METHOD.

Local exchanges.—There is no immediate prospect that wireless telephony will take the place of local exchanges. The difficulty in regard to the number of tunes can be overcome, but the fact remains that high frequency oscillations cannot be transmitted over wire and hence each subscriber must have his own generating station. At the present time no method

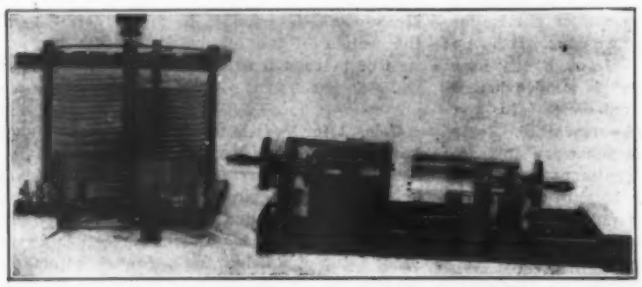


FIG. 29B.—INTERFERENCE PREVENTER.

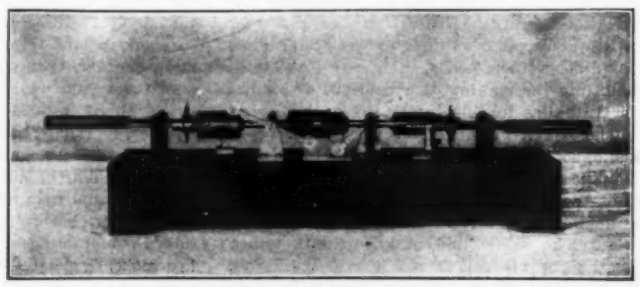


FIG. 29C.—INTERFERENCE PREVENTER.

* Copyright, 1908, by the American Institute of Electrical Engineers, and republished from its Transactions.

† U. S. application, 350,199, December 31st, 1906.

‡ U. S. application, 366,528, April 5th, 1907.

§ This method may, of course, be used for duplex working in wireless telegraphy. As some question has been raised in regard to the capacity of wireless telegraph lines the writer would say that he has received messages at the rate of 250 words per minute by wireless and is now experimenting with apparatus designed to give 500 words per minute. With duplexing this gives 1,000 words per minute, or 60,000 words per hour. The manager of one of the largest cable companies has stated (London Daily Mail, September 24th, 1907) that all the transatlantic cables together send 24,000 words per hour. It would appear, therefore, that if capacity alone be considered a single station on each side of the Atlantic can handle more traffic than all the present cables. It should be pointed out, however, that the mere ability to handle the messages is not sufficient, and that unless the wireless telegraph companies obtain land facilities equal to those at present enjoyed by the cable companies they cannot handle the traffic as efficiently, i. e., cannot deliver a message from New York to an individual in London and receive a reply in the same time.

is known which would be practical if placed in the hands of a subscriber. If such means should be found it would be very convenient to call up directly instead of through an exchange, but as I see it there are no immediate prospects of this.

Long-distance lines.—I believe, however, that there is a field for wireless telephony for long-distance lines. The present long distance lines are very expensive to construct and to maintain, and a storm extending over any considerable section of country inflicts considerable loss on the telephone companies. Moreover, the distance of transmission is limited by the electrostatic capacity of the line, as I understand it. Wireless telephony would have the following advantages:

1. The initial cost would be very much less than that of wire lines.
2. The maintenance would be practically negligible in comparison.
3. In case of any breakdown, it would be right in the station and not at some unknown point outside on the line.
4. The depreciation would be comparatively small.
5. The number of employees required would be smaller.
6. The transmission is better, and as there is no distortion of the speech, the working distance is, it is believed, considerably greater.
7. The flexibility is greater. With wire lines a telephone company may not be able to give a Boston subscriber a line to New York, while having lines from Boston to Chicago and from Chicago to New York free. Operating wirelessly, the wireless circuit normally used for operating between New York and Chicago and between Boston and Chicago could be used to operate from Boston to New York.
8. No right of-way need be purchased and franchises, it is believed, are not necessary.

It will be noted that I have carefully avoided mentioning any of the disadvantages of wireless telephony for long-distance work. I presume this is because I am not a telephone engineer. I hope the defects will be supplied by the experts who are familiar with telephone operation and therefore better able to point out the defects. Before leaving this part of the subject I would say that I think the question of interference has been worked out to such an extent that no serious difficulty need be feared in that direction.

Transmarine transmission.—Wireless telephony is peculiarly suited for this class of work. Pupin's ingenious and beautiful method has been successful at Lake Constance, Switzerland, I believe, but even assuming that deep-sea cables of this type could be laid and operated successfully, they would nevertheless be very much more expensive than wireless telephone stations. It is believed that wireless telephony will come into extended use for this purpose. Even without further development telephonic communication could be established between Norway or Denmark or Germany or Spain and Great Britain; between Sardinia and Corsica and France and Italy; between France and Algeria, between Australia and Tasmania and New Zealand; between the United States and Cuba and Porto Rico, etc., were it not that it is at present forbidden by law.

As regards telephonic communication between England and America, my measurements show that this should be possible with an expenditure of approximately ten kilowatts and suitably large towers, say 600 feet high, or with some of the new forms of antenna. Whether such a transmission would be commercially valuable or not is another matter. Personally I do not see that it would, but when I remember that at the time when the telephone was first being introduced a number of eminent business men decided that the house-to-house printing telegraph would be more of a success commercially than the telephone for the reason that no one would want to do business unless he were able to have a record of the transaction, I must admit that there is a possibility of my being mistaken in this.

Wireless telephony from ship to ship.—Here, of course, wireless telephony occupies a unique position. Wireless telegraphy has the disadvantage that a telegraph operator must be carried. The additional expense is an objection in many cases. The proposition that the captain or mate should also be a telegraph operator has not met with favor. Anybody, however, can operate the wireless telephone and almost every vessel carries an engineer capable of repairing the electrical apparatus in case of accident. The final arrangements will, I believe (if we can prevent the governments from carrying out their proposed laws, forbidding wireless telephony), be this: that passenger vessels will carry a telegraph operator and use the telephoning apparatus for ordinary work and for telegraphing where it is desired to communicate over long distances. Other vessels will use the telephone alone.

Wireless telephone from ship to local exchange.—This also will, I think, have considerable value, as enabling the captain of a vessel to communicate, by relaying over the wire line, with the owner of the ship, or enabling a passenger on a vessel to communicate with friends on shore.

Range of wireless telephony.—1. *Atmospheric absorption.*—The great obstacle to long-distance wireless telegraphy and telephony is atmospheric absorption. For short distances up to 100 miles in the temperate zone there is little difference between the strength

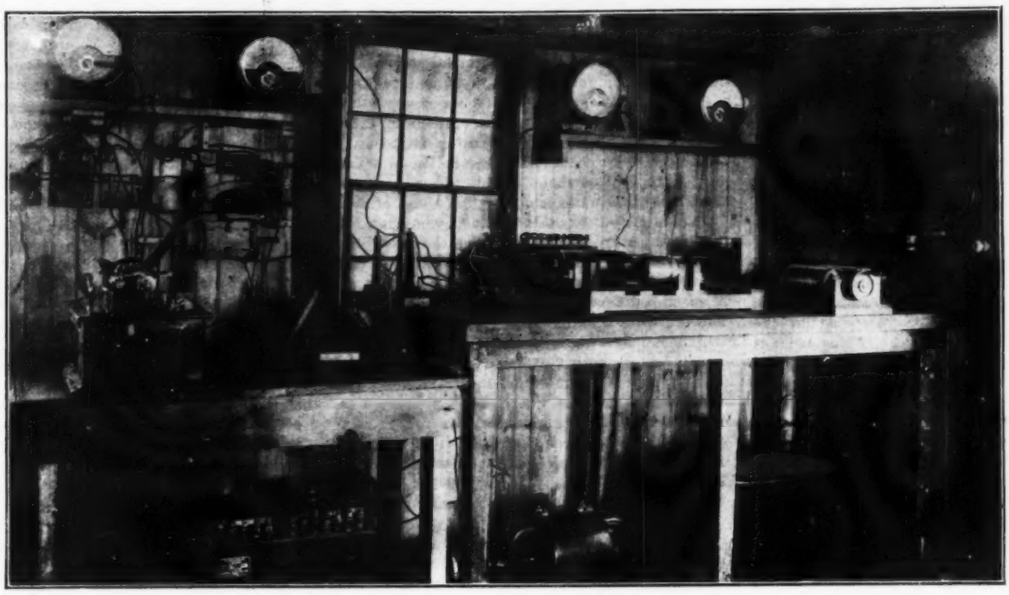


FIG. 30.—PHONOGRAPH TRANSMITTING MUSIC AND SPEECH WIRELESSLY.

FIG. 31.—TALKING BY RELAYS FROM A LOCAL CIRCUIT.

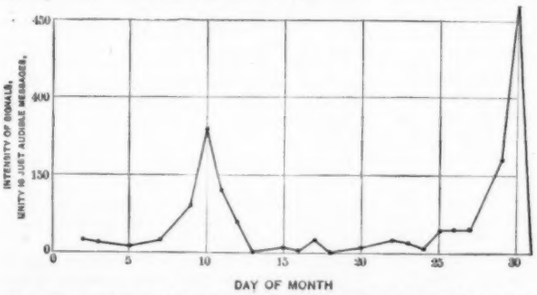


FIG. 32.—CURVE SHOWING STRENGTH OF MESSAGES SENT FROM MASSACHUSETTS TO SCOTLAND.

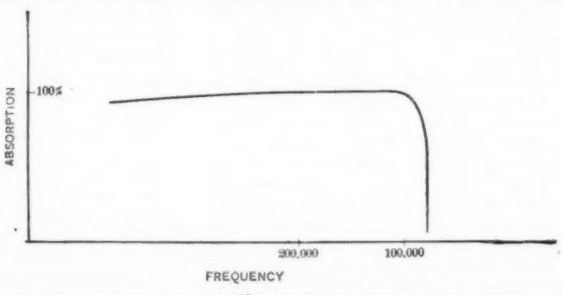


FIG. 33.—GENERAL CHARACTER OF TRANSATLANTIC MESSAGE CURVE.

of the signals at one time of the day and another. As soon as the distance is increased much over 100 miles for the temperate zones and 40 or 50 miles for the tropics the signals at night are very irregular and there is great absorption during the day time. The daylight absorption may be so great that less than a tenth of one per cent of the energy transmitted gets through. Some nights will be as bad as daytime, while on other nights there will be apparently no absorption.

Fig. 32 is a curve showing the strength of the messages transmitted between Brant Rock, Mass., and Machrihanish, Scotland, at night, during January, 1906. Nothing at all was received that month during daytime.

The change in the strength of the signals is very sudden. In working from Brant Rock to Porto Rico, a distance of 1,700 miles, the strength of the signals with short wave lengths would fall off to one one-thousandth of their former value during a period of less than fifteen minutes, while the sun was rising.

Early experiments* showed that the absorption was greater as the wave length was increased and the effect was at first attributed to absorption in the neighborhood of the sending station, and was thought to increase continuously with the wave length.* This fluctuating absorption at one time appeared to place a fundamental obstacle to commercial wireless telegraphy, as telegraph engineers will easily appreciate the impossibility of operating telegraph systems with circuits where the strength of the received signals may fall to one-thousandth of its value or rise to a thousand times its value in the course of a few minutes.

It was therefore considered absolutely essential, in order to decide whether long-distance wireless telegraphy was commercially possible or not, to investigate this phenomenon fully. As a preliminary the station at Brant Rock sent to four or five other stations at varying distances and comparative readings were taken. The following table shows the general character of the results obtained:

Station.	Distance.	Strength of Signals Received on Worst Nights (Strength of Unabsorbed Signals Being Taken as 1000).
Company's cottage...	200 yards	1,000
Lynn	30 miles	1,000
Schenectady	170 miles	500
Philadelphia	270 miles	300
Washington	400 miles	150
Machrihanish	3,000 miles	1

These experiments proved conclusively that the absorption did not take place in the neighborhood of the sending station, because the strength of the signals received at nearby stations was the same during the day as during the night, while there was great variation in the strength of signals received at stations farther away.

It was also found that the absorption at a given instant was a function of the direction as well as of the distance, since on a given night the signals received by stations in one direction would be greatly weakened, while there would be less weakening of the signals received by stations lying in another direction, while a few hours or a few minutes later the reverse would be the case.

This was thought to be connected with the coming weather conditions, but before this fact is proved a much larger amount of data must be collected. Through the kindness of the U. S. Weather Bureau I was enabled to obtain a chart of the magnetic variations and on comparison of these with the absorption between the Massachusetts and Scotland stations there appeared to be a quite definite relation, i. e., the greater the absorption the greater the magnetic variation. Here also, however, much more data is needed before arriving at a definite conclusion. The fact that the absorption did not take place in the neighborhood of the sending station having thus been definitely settled the next point to be investigated was whether or not there was any way of overcoming it.

The fact that variations in the absorption occurred with extreme rapidity, the absorption increasing sometimes a hundredfold in a single minute, and at night, when the effect could not be due to the sun directly, seemed to indicate that the body producing the absorption, whatever it was, was not in a state of continuity but was broken up into masses like clouds.† This also was in accordance with some experiments made in Brazil in 1905.

From optical theories it is known that where the absorption is produced by conducting masses of a more or less definite size the absorption is to a certain extent selective. The next point in the investigation was, therefore, to determine whether there was any possibility of this being the fact in the case of the absorption of wireless signals.

Comparative tests were therefore made of the absorption at night and during the day between Brant Rock and Washington, with wave lengths varying from a fraction of a mile up to four or five miles. It was found that the absorption did not increase continuously with the wave length, but reached a maximum and then fell off with great suddenness.

Fig. 33 shows the general character of the curve, the ordinates referring to the amount of the absorption and the abscissas to the wave frequency.

It may be noted that the absorption is a maximum at a frequency of about 200,000 per second, nine hundred and ninety-nine thousandths (0.999) of the energy being absorbed at this frequency during daylight, while for a frequency of 50,000 the absorption does not appear to be appreciable. Longer experiments, of course, might show some absorption, but in any case it is of a different order from the absorption for the shorter wave lengths.

Experiments were then made between Brant Rock and the West Indies, a distance of 1,700 miles, during the spring and summer of 1907. It was found that the results were of the same character, i. e., that while there was greater absorption for frequencies of 200,000 there was comparatively little absorption for frequencies in the neighborhood of 80,000, and messages were successfully transmitted in daylight with this latter frequency. No messages were received in daylight with the higher frequency, though messages transmitted from the same station and with the same power and frequency were officially reported as having been received at Alexandria, Egypt, a distance of approximately 4,000 miles.

The fact that these experiments were made during summer weather, and the receiving station was in the tropics, and the fact that the distance, 1,700 miles, was practically the same as that between Ireland and Newfoundland definitely settled the question as to whether long-distance wireless telegraphy was a commercial possibility or not, and the results were therefore published.*

Since the publication of the above results transmission has been accomplished by means of these long waves over still greater distances during daylight. Sig. Marconi early in October, 1907, succeeded in operating between Glace Bay, Nova Scotia, and Clifden, Ireland, a distance of more than 2,000 miles, at a frequency of approximately 70,000. The same messages were received at Brant Rock, Mass., a distance of nearly 3,000 miles.

Still more recently Capt. Hogg of the "Glacier" has written that during the southward passage of the Pacific fleet he received messages from the station at Brant Rock, Mass., while off Cape Ste. Roque, Brazil, S. A. The frequency used for sending was approximately 80,000, and the messages were received with the very interesting and sensitive silicon receiver invented by Mr. Pickard. This distance of 3,000 miles is the greatest yet achieved by wireless transmission during daylight and would indicate that with the use of suitably high towers much longer distances can be reached.

2. *Range of wireless telephony and wireless telegraphy compared.*—For the same power it is possible to telegraph to a farther distance than to telephone. Distinct speech depends upon the presence of harmonics of a frequency as high as 1,200 per second. The amplitude of these harmonics is, according to some rough experiments made by the writer, only about one per cent of the fundamental frequency. Consequently, with a perfectly modulated transmitter one hundred times as much energy would be necessary to telephone a given distance as to telegraph. It fortunately happens, however, that a carbon transmitter, and also the circuits in which it is used, can be so constructed as not to modulate perfectly, but can be arranged so as to accent the higher harmonics.

With transmitters arranged for the purpose good transmission has been obtained with thirty times the energy required to produce audible telegraphic signals. By still further modification the power required has been reduced to approximately ten times that necessary for telegraphing, curiously enough without noticeably distorting the character of the speech. There is one fact, however, which prevents the ratio from being as large practically as the instruments show, i. e., speech can be satisfactorily understood with a less increase of power above a minimum audibility than telegraphic signals.

The amount of power necessary for wireless telephony may therefore be taken as approximately five to fifteen times that necessary for wireless telegraphy; i. e., under the same circumstances and for the same power the wireless telegraph will carry two to four times as far. The difference in range would be very much greater also but for the curious fact that there is much less falling off with sustained oscillations than with intermittent groups of waves, even though the frequencies are identical.

This fact has been repeatedly determined by sending between Brant Rock and Brooklyn on the same frequency, using in the one case spark-produced [illegible] of waves and in the other the high-frequency dynamo. The difference in the falling off for the same frequency and energy is very great, but further work is necessary before anything very definite can be said about it or the reasons finally determined.

Every investigator is necessarily largely indebted to the work of others. In my own case the obligation is very extensive for two reasons, first because of the large extent of ground covered and the great number of methods developed and tested, and secondly because the phenomena dealt with had never been quantitatively investigated and it was therefore necessary so to speak to construct the foot rules and micrometers and lathes before the work itself could be begun.

First and foremost my thanks are due to Prof. Kintner for his assistance in the early work done at Allegheny. To Prof. Elihu Thomson, Dr. Steinmetz, Mr. Alexandrson, Mr. Green, Mr. Reist, Mr. Dempster and Mr. Geisenhoner of the General Electric Company, to Mr. Guy of the DeLaval Steam Turbine Company, Mr. Fisher of the Standard Underground Cable Co., to Mr. Brashear of Allegheny, to Mr. Hodge, formerly of Queen & Co., to Dr. Rosa, and Dr. L. W. Austin of the Bureau of Standards, I am in no case slightly, in many cases deeply, indebted.

I am also greatly indebted to those who have been associated with me as my assistants during the period from 1896 to 1908, i. e., Messrs. Thiessen, Bryant, Stein, Davis, Boyle, and Bennett in the experimental work, Mr. Mansbendel in drafting and design, and Mr. Williams in the manufacture of the apparat[illegible] *

REFINING TIN BY ELECTROLYSIS.

THE electrolytic method, which is now used so largely in refining copper, silver, and gold, has not hitherto been applied to tin because this metal is easily purified by other methods. The following process, however, has been employed to some extent. Anodes of tin containing 10 per cent of other metals are placed in a 10 per cent solution of sodium sulphate, with cathodes of pure tin or tin-plate, and traversed by a current of 0.06 ampere per square inch at a pressure of less than one-fifth volt, the temperature being kept about 194 deg. C. If the electromotive force is higher, say three-fifths volt, the electrolyte is decomposed and a precipitate is deposited on the cathode with the tin. Any other metal present, in solution, colloidal solution, or suspension, is similarly deposited on the cathode, even with the lower electromotive force. Hence violent agitation, which would bring into suspension the impurities which fall to the bottom from the dissolving anode, should be carefully avoided. About one per cent by weight of sulphur should be added to the bath before each renewal of the anodes. The sulphur combines with the metals of the anode and acts as a depolarizer, so that the electrolysis can be commenced with a low voltage. With this addition the same bath can be used continuously for months. Finally, as it is necessary to use many electrodes, connected in multiple, and to employ a very low voltage, the equable distribution of the current among the electrodes is beset with difficulties, as the slightest difference of resistance of conductors and contacts may have an important effect.

This process is in use at an establishment near Liverpool. The cost of installation for an annual production of 1,000 tons of pure tin is estimated at $25,000. The cost of operation is $40 per ton, and the net profit derived from the recovery of the other metals is at most $28 per ton (of pure tin). Hence the process is profitable only if there is a great difference between the market prices of crude and pure tin. On the other hand, the risk is great because of the fluctuations in the price of tin, since, for a production of 1,000 tons annually it would be necessary to keep a stock of 150 or 200 tons constantly on hand, and the world's yearly output of 90 per cent tin does not exceed 1,000 tons.

Cement for Knife Handles.—Melt together 600 parts of rosin, 150 parts of sulphur and 250 parts of iron filings, pour some of this mixture, hot, into the hole in the knife handle and push in the likewise heated tang of the knife.

* A mathematical explanation of this supposed fact was given by Dr. Fleming, "Principles of Electric Wave Telegraphy," pages 617-618, 1906, the following conclusions being reached:

"Accordingly, the chief part of the weakening of the wave by sunlight is done in the neighborhood of the sending antenna, where the magnetic force *H* is greatest, and it is more sensible for long and powerful waves than for short and feeble ones. This agrees with the observations of Mr. Marconi."

† Electrical Review, May 18th, 1906.

* The Electrician (London), July 26th, 1907.

* Where either the idea of the invention or the means for carrying it out or both were due to an assistant, the invention has been patented in his name, and it is so referred to in the present paper.

Where the invention was made solely and entirely by the writer without assistance it has been so patented and is referred to in the paper by number only, the name being omitted to avoid unnecessary repetition.

How much the writer is indebted to his partners, Messrs. T. H. Given and Hay Walker, Jr., for the means for carrying out the work and for the wise and far-sighted policy which has enabled the development to be carried on in the most efficient way only those who have themselves been engaged in the development of a new art can fully appreciate.

A NEW PROCESS FOR REDUCING COPPER.

A METHOD APPLICABLE TO ORES OF ALL GRADES.

BY O. FROELICH.

COPPER pyrites ($FeCuS_2$), the most important ore of copper, is a very stable compound and, consequently, it is usually reduced by roasting, smelting, weathering, or these operations combined. When the ore, in small pieces, is roasted in a current of air it becomes converted, first into the sulphates, and finally into the oxides of copper and iron, but the transformation is never complete, so that the product is a mixture of sulphates, oxides, and unaltered ore. The application of smelting depends on circumstances, especially the character of the gangue. It is applied both to roasted and to unroasted ores. Both closed and open hearth furnaces are employed, and either an oxidizing or a reducing effect is obtained, the former by an air blast, the latter by adding coal or coke. Fluxes are often added for the purpose of eliminating the iron in the form of slag.

The result of the operation, like that of roasting, is always imperfect. Weathering is a slow roasting or oxidizing process which is employed, in connection with solutions of ferric sulphate and other oxidizing agents, instead of roasting, especially for ores containing much iron pyrites.

The reduction of copper is generally effected by a succession of roastings and smeltings. The crude metal thus produced is refined either by a final smelting with reducing agents or by electrolysis. Common refined copper contains some tenths of one per cent of impurities, but electrolytic copper is either chemically pure, or pure to a few hundredths of one per cent. The electrolytic process costs $24, the common process only $7.25, per long ton, but the former simultaneously yields all the silver and gold which the ore may contain, and which must be obtained by special processes when the copper is refined by smelting.

The cost of roasting and smelting includes labor, ore, coal or coke, and their transportation. Steam, gas, or water power may be employed to furnish current for the electrolytic process. In all cases the gangue, which often constitutes nine-tenths of the weight of the ore, must be removed by smelting. Great volumes of sulphur dioxide are evolved which are sometimes converted into sulphuric acid but are usually discharged into the atmosphere. The most important recent improvements are the partial substitution of chlorine for oxygen in roasting and the utilization of the heat generated by the oxidation of the sulphur in connection with a process analogous to the Bessemer steel process.

In chlorine roasting the ore is first subjected to a partial oxidizing roasting and then heated with common salt. Cupric chloride ($CuCl_2$) and cuprous chloride (CuCl) are formed. The former is dissolved out with water, the latter with acids or brine, and the copper is precipitated by adding metallic iron. This method, which is applied in Germany to the Rio Tinto ore brought from Spain, gives a much greater yield of copper than the common process.

In the Bessemer process the ore is smelted, with other substances, in an iron converter, with the aid of a blast of hot air. The newest variety of this method, direct pyrites smelting, yields a crude copper which requires only a little refining in the smelting furnace to become marketable. The Bessemer process requires little or no coal, but is not applicable to ores containing less than 4 per cent of copper. Like the older methods it contaminates the atmosphere with sulphur dioxide, unless a sulphuric acid factory is included in the plant.

The new method described below can be applied, at the mine, to all copper ores, and dispenses almost entirely with coal, thus saving transportation charges. Furthermore, it does not evolve sulphur dioxide but recovers the sulphur in the solid form. It is a web method and its cost is made up essentially of the three items of labor, iron for precipitation, and the power required to drive the stirrer. This power is not necessarily obtained from coal, but may be derived from the most available source.

In this new method, which is being introduced into practice after years of development, the solvent employed is a solution of ferric chloride, which converts both the sulphides and the oxide of copper into chlorides, with the precipitation of ferric oxide or its hydrate. For example,

$$3CuO + 2FeCl_3 = 3CuCl_2 + Fe_2O_3$$

The now abandoned Doetsch process likewise employed ferrichloride, in connection with weathering, but after being continued nearly four months left a residue containing ½ per cent of copper. The liquid was regenerated by chlorine gas.

In order to avoid these defects I employ a spiral stirrer, which may be used with advantage in all slow and uncertain reactions and produces a rapid circulation of liquid with little expenditure of power. In the center of the vat containing the ore and the ferric chloride solution is a vertical hollow cylinder of wood or clay, provided with small inlets at the bottom and large outlets at the top, and containing a rapidly revolving flat-bladed screw, or stirrer, also made of wood or clay. By this device the whole of the liquid is drawn upward through the cylinder once a second and caused to flow rapidly through the ore which, broken into lumps as big as a hazel nut, surrounds the lower part of the cylinder. As the reaction is accelerated by heat, the vat is surrounded by a jacket filled with water, which is heated by the injection of steam, or the vat may be heated by a current of steam or hot water flowing through a clay or protected leaden pipe immersed in the liquid. Although the stirrer makes 450 turns per minute, it consumes only 15, 33 and 51 horse-power, for vats holding 777, 2,188, and 2,824 cubic feet respectively.

If the ore is finely divided only a shallow layer can be treated, because it offers great resistance to the flow of the liquid, and it often becomes caked. Hence it is better to use coarsely ground ore.

The same stirring apparatus is used in precipitating the copper by iron, and in regenerating the liquid.

Copper pyrites, before being treated with ferric chloride, is subjected to a preparatory treatment of my invention. The broken ore is heated to a temperature between 400 and 600 deg. F. without access of air. By this means one-fourth of the sulphur is driven off and the ore is made more soluble, so that more than 90 per cent of its copper is extracted by the ferric chloride solution. Probably the copper pyrites is converted into the more soluble copper glance (Cu_2S) and ferrous sulphide by the following reaction:

$$2FeCuS_2 = S + Cu_2S + 2FeS$$

The ore turns dark blue or dark brown but no copper oxide is formed if air is excluded during the heating. By this preliminary treatment the evolution of sulphur dioxide is entirely avoided, so that the process can be carried on in densely populated districts.

Some varieties of gray copper ore, which contain antimony and arsenic instead of sulphur, would probably resist the action of ferric chloride, but all the gray copper ores that I have tested dissolve readily, after undergoing the preliminary heating. The ferric chloride solution dissolves all other copper ores without preliminary heating.

By my process, therefore, the copper can be extracted very completely from practically all ores, including the richest partially smelted products containing 33 per cent of copper, and the poorest natural ores, containing less than 1 per cent.

The operation of extraction occupies not more than 72 hours, the time varying little with different ores.

The copper is precipitated from the solution by iron in the stirrer vat which is strongly heated. While this operation, as it is often conducted, even with heat and moderate agitation, gives a precipitate containing only 90 per cent of copper, my apparatus and method yield fine red grains of copper nearly free from iron, mixed with a few grains of a black magnetic oxide of iron and of other metals, especially arsenic and antimony, which are separated by methods based on differences in specific gravity.

I thus obtain, by precipitation alone, a marketable and nearly pure copper, and, by the employment of certain simple processes of purification, a product as pure as electrolytic copper.

The best test of the purity of copper is the fineness of the wire that can be drawn from it. My precipitated copper, fused in a reducing flame, can be drawn into wire 1/750 inch in diameter, which indicates a degree of purity that should make it suitable for all electrotechnical purposes.

For the economy of the process it is necessary to restore the liquid, after the copper has been precipitated, to its original condition of a solution of ferric chloride. In the Doetsch process this was done by chlorine, the production of which entailed additional expense, but in my process, owing to the efficient action of the stirrer, it suffices to blow air through the heated and rapidly agitated liquid. This regeneration is accomplished in 24 hours, during which the gradual increase of ferric chloride can be followed by simple tests.

Most of the iron of the ore is dissolved, in the form of ferrous chloride, so that the iron content of the liquid increases both during extraction and during precipitation, while the amount of chlorine remains constant. The effect of the air blast is to convert the ferrous chloride into ferric chloride and to precipitate, in the form of hydrated oxide, the excess of iron that has been taken up from the ore. This hydrated oxide, after being washed, dried and slightly roasted, may be used as a pigment.

The silver and gold of the ore are also recovered by my process. After the extraction of the copper these metals exist partly in the liquid as dissolved chlorides, partly in the spent ore as metal or chloride. From the liquid they are recovered by electrolysis, and mixed with copper, by a brief application of a weak current. The spent ore is washed and treated successively with various solvents, ammonia for silver chloride, potassium cyanide for gold, etc., the solutions being enriched by applying them to numerous parcels of ore. The gold and silver are finally recovered by the usual methods.

The new method furnishes an additional source of revenue in the recovery of sulphur, which is worth 1/10 the price of copper, so that 10 per cent of sulphur is equivalent to 1 per cent of copper. One-fourth of the sulphur is volatile red and can be condensed and collected, during the preliminary heating. Most of the remainder is set free during the extraction of the copper and remains mixed with the spent ore. It can be recovered most completely by heating the residue to 850 deg. F. or higher in a closed vessel, connected with a sublimation chamber, but a very satisfactory yield is obtained by heating to 250 deg. F., at which temperature the sulphur melts and runs together.

The cost of the entire process can easily be made less than that of the usual methods, especially when cheap power is available and much sulphur, silver and gold are recovered. The initial outlay is also comparatively small.

The fact that the process is applicable to all varieties and grades of ore (with the possible exception of some gray ores) is of great practical advantage in mines of copper pyrites in which the upper strata are oxidized. As the stirrer may be driven with any power and the vat heated with any fuel, it would be possible to operate mines in well-wooded mountainous districts with abundant water power in the form of small streams almost independently of the outside world.

The advantages of the process, in short, include: avoidance of sulphurous acid fumes, applicability to nearly every variety and grade of ore, use of any available power and fuel, independence of the character of the gangue, use of coarsely ground ore, production of pure copper without electrolysis, recovery of silver, gold, and sulphur, reduction of cost of plant and operation.—Condensed from Elektrochemische Zeitschrift.

PETROLEUM SOAP.

IT is asserted that petroleum and mineral oils in general can be saponified and converted into true soaps by a process in which their hydrocarbons are first oxidized. For example, 10 parts of animal oil or melted fat and 10 parts of vegetable oil are mixed with 100 parts of petroleum. A solution of 9 parts of caustic potash in 12 parts of water is added and the mixture is stirred until saponification begins (from ½ to 1 hour). About 3 parts of boric acid or some other compound of boron are then added in the following manner: The boron salt is boiled with 12 parts of water until it is half dissolved and the solution and undissolved residue are poured together into the soap mixture, which is well stirred and allowed to stand two or three days, during which it gradually thickens. If it is boiled when in the proper condition, soap is produced.

In Victoria, Australia, the State mining law requires 70 cubic feet of air per minute to be supplied to each miner working in the mine, and that the air in the mine shall not contain less than 20 per cent oxygen, nor more than 0.3 per cent carbon dioxide. The Western Australia Mining Commission in 1905 considered that not more than 0.15 per cent carbon dioxide should be allowed, and that it should not be difficult for mines to meet that demand. Dr. Angus Smith, of the English Mining Commission, recommends 0.24 per cent carbon dioxide as the limit of impurity in mine air.

JOINING SIMPLON WITH LOETSCHBERG.

AN ACCOUNT OF AN IMPORTANT FEAT IN RAILROAD ENGINEERING.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE construction of the Loetschberg tunnel and railroad section is undoubtedly the most extensive railroad work in Europe at the present time, as the entire cost of the tunnel together with the railroad approaches on either side of it, not including the rolling stock of the new section, is to be somewhere near $15,000,000. For some time there has been the need of a more direct route from the north to the south of Switzerland in order to proceed from the important railroad center of Berne toward the south and thus make the connection with the railroads in the north of Italy, of which Milan is the principal center. While the completion of the Simplon tunnel gave the desired north and south connection, the trains which left Berne for the Simplon were obliged to make a long detour toward the west. This is due to the extensive mountain region of the Bernese Oberland lying across the direct line connecting Berne with the Simplon, and the railroad line is obliged to go around the mountain district instead of across as will be done when the new route is completed. This detour, which is made by way of Lake Leman and the whole length of the Rhone valley as far as the Simplon, makes the distance at least twice that of the Loetschberg route. The present route from Berne to the Simplon tunnel is about 130 miles long, while the new line will not be much more than 60. This difference will be felt specially in the case of through trains such as the Paris-Milan express and trains coming from other cities in the north of Europe.

The writer has visited the work of the new tunnel near the Simplon, and noted the extensive plant erected in the valley of the Lonza for the south end of the tunnel. As this point lies far up in the mountains in a region which is difficult of access, it is not often photographed, and the views shown herewith are probably the first of the kind to be published in the technical press.

An idea will be had of the extent of the work when it is known that the length of the new tunnel is 8.53 miles while the Simplon is 12.5. However, the Loetschberg tunnel has a larger section than the Simplon, as it is designed to receive a double track throughout the whole length, while the older is much narrower and has a single track line with a turnout in the middle.

The new railroad section will be double track and operated by electric locomotives and cars. It connects on the northern side with the lines at Frutigen, which is as far as the railroad can run in the direction of the Bernese Alps. From this point, which is at an altitude of 2,470 feet, the road will proceed up a steep gradient and follow the picturesque valley of the Kander River, running on a double curved route which has a number of tunnels along its course. This part of the line terminates at the high plateau of Kandersteg (4,050 feet) and is surrounded by the lofty mountain peaks and glaciers which are in the neighborhood of the Jungfrau. At Kandersteg the line enters the north end of the tunnel, mounting a slight grade as far as the 0.72 mile point, and then

GENERAL VIEW, SHOWING THE PLANT AT THE SOUTHERN END OF THE TUNNEL.

descends toward the south end. This latter point lies at about the same altitude as the north end. From the tunnel end, which is located at Goppenstein, the road descends the wild and precipitous valley of the Lonza to the south in a winding course over many bridges and through tunnels, and upon reaching the Rhone valley it makes a sharp turn to the east and follows along the side of the mountains which border this valley, the road being constructed on a cutting in the rock for most of the distance, and it passes over many of the mountain torrents which flow into the Rhone. By a gradual descent which covers some 20 miles, the railroad finally arrives at the mouth of the Simplon at Brigue and at this point it connects with the existing railroad. Owing to the nature of the mountain region, the construction of the roadway apart from the tunnel involves a considerable amount of work in the way of cuttings, tunnels and bridges. The entire enterprise is under the control of the Bernese Alps Railroad Company, who submitted the project to the government of the Berne Canton and had it adopted in 1906, with the stipulation that the railroad should not have gradients higher than 27 per cent on the approaches to the tunnel, and that the length of the tunnel should be 13,735 meters (8.53 miles). Accordingly the company, in which there is considerable French capital, made arrangements with the present contracting firm that the work of constructing the tunnel should be completed for $7,400,000, while that on the two approaches was estimated at the same figure, making a total of $14,800,000. This does not include the electrical equipment.

SOUTH END OF TUNNEL NEAR GOPPENSTEIN.

By referring to the views of the south end of the tunnel at Goppenstein, it will be seen that the plant which is located at this point is an extensive one. There is one of about the same kind located at the north end at Kandersteg, and the whole number of workmen employed within the tunnel and on the premises at both ends is about 3,200. The mouth of the tunnel at Goppenstein lies at a very high altitude at the foot of the lofty mountains of the Bernese Oberland, among which may be seen in the distance the peaks and glaciers of Balmhorn and the Blumlialp. One view shows the mouth of the tunnel and the different buildings of the plant, while in another will be noticed the general shape of the tunnel which has a half-circle section at the upper part, with a short straight part, making a total height of 21 feet 7 inches and a width of 27 feet 4 inches.

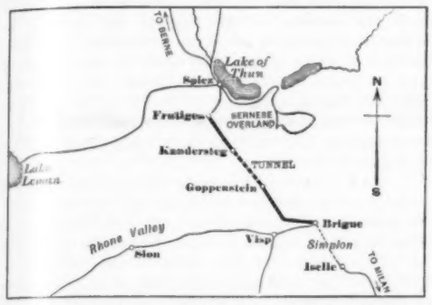
Compressed air drills are used for tunnel boring, the air being supplied by an extensive plant erected on the premises. The four compressors are individually driven by electric motors, and the current comes from a distant hydraulic plant. Two furnish air at 10 atmospheres pressure for use in the rock-drills, and these are each driven by belt from a 300-horse-power electric motor. The other two give air at 120 atmosphres for the numerous compressed air mine locomotives in use, and they are driven by two electric motors of 200 horse-power. Air is fed from each set of compressors into a corresponding reservoir from which it is led by pipe lines.

The current which is required for operating the compressor plant, as well as the air-blowers for the tunnel, is obtained from two different hydraulic plants on the Lonzo stream, and these lie in the valley below and at some distance from the mouth of the tunnel. These plants combined have an output of 10,000

horse-power, but this amount is not all used for the tunnel work, as a good part of it goes to supply carbide works in the region.

The drills which are used in the tunnel are of two kinds, a compressed-air percussion drill of several sizes and makes, and a hammer drill. They are employed for special drilling work and excavating operations. The compressed-air locomotives are used with various kinds of material cars in order to take out the rock, and another sort with benches serve to convey the workmen in the tunnel.

An air supply is furnished for the tunnel by a set of motor-driven blowers which deliver the air to a



MAP OF NEW TUNNEL AND RAILROAD, SHOWING SHORT ROUTE FROM BERNE TO MILAN.

point near the end of the tunnel work, where relay air fans are placed which deliver the air to the field of operations. When the work is completed these blowers will be retained for ventilating purposes.

On the southern side the rock is formed of gneiss with masses of quartz, which makes the drilling more difficult than at the other, where the rock is limestone for the most part. At last accounts the tunnel had advanced to 9,240 feet at the south end, while the length at the other side somewhat exceeds this.

Connection is made between the plant and the railroad at Brigue by means of a narrow-gage working railroad and this is laid upon the route which has been prepared for the final railroad line. This route will be enlarged when it comes to laying the tracks for the standard-gage railroad.

THE TOOL STEEL SENSATION.

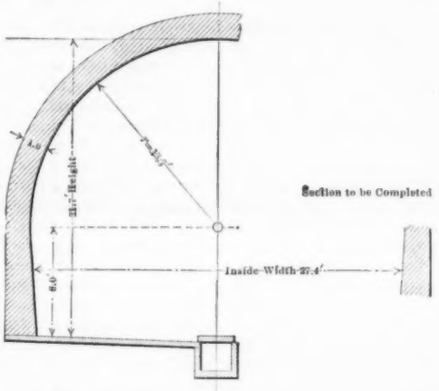
WHEN a few weeks ago Prof. Arnold startled an audience by announcing the advent within a year of a tool steel that would do from three to four times as much work as even the best of its predecessors, he told either too much or too little.

The first effect of Prof. Arnold's prophecy was to give the impression that one firm only out of all those in Sheffield made the new steel, and that its invention was in the nature of a discovery. As a matter of fact, nothing could be further from the truth. Experiments are continually in progress in all the best works. There are now on the market many steels which are quite capable of doing from three to four times as much as is generally expected of them. There is then absolutely nothing in the nature of a revolution in the production of these high duty steels. They are produced by a natural process of development from what has gone before, and though vanadium enters into their composition, we need not tell our readers that that element is no new ingredient in tool steels. An eminent steel maker has put the matter very effectively by saying that the claim for the new steel reminds him of the man who discovered a new drink. It turned out to be whisky and soda, but with twice the usual amount of whisky. So it is with the new steels; they are simply a development of what had preceded them. The best makers, it must be remembered, never cease experimenting, and they keep on continually improving the steel they send out. But they do not continually change the brand or the name of the steel any more than a maker of a lathe or a dynamo gives a new name to it every time he effects an improvement in the design. Many of the steels now on the market are called by the same names that they have been called by since they were made; but, as a matter of fact, month by month improvement has been made in them, and many of them are far more durable than their prototypes. The fact is that the maker knows enough now of the mystery of high-speed steels to give the purchaser anything he cares to pay for. Anyone who needs special steels can have them by paying for them.

We have spoken so far rather of the commercial than of the technical aspects of the "new" steel, because, for the moment at any rate, it is the commercial aspect that is of greatest importance. But while the commercial aspect is, for the moment, the more important, the technical points are extraordinarily fascinating. Take, for example, the question of water hardening. That these special steels can be hardened in water no one will deny, and that very extraordinary results are obtainable thereby is certainly true. But it is as certainly true that exceptional precautions must be observed, and that even then the metal is far more likely to split than if oil or air hardened. Moreover, the safer course provides a steel that will do all that most users require. Some makers, indeed, say that water hardening as a general thing will never be used. That, of course, remains to be seen. Another fascinating question is the possible future of tool steels. Every maker now and then produces a tool which is far and away in advance of any other he himself has made. As far as he knows, its composition is precisely the same as that of a score of others, and the analysis shows no difference. It is therefore believed to be due to the treatment in hardening. There is no doubt a best temperature at which to plunge, and since the heat is in any case excessively high—as near as possible to the melting point—slight differences are only secured by chance—at present. A tool of the latest kind, produced by a well-known maker, was put in the front rest of a lathe, while a standard H.S. tool was put in the back rest. The feed for both was ⅛, and each tool made a cut ⅛ deep, the latest tool breaking the scale for the old tool. The speed was between 45 feet and 50 feet per minute. The old steel ran for 11 inches and failed, the new for 14 feet 6 inches before giving out. We quote these results to show what possibilities lie in tool steels. These figures, and others, we shall deal with in more detail later, but for the moment they are given to show that the tool steel maker has plenty of scope for advancement. The steel is capable of wonderful things, and we do not doubt that the manufacturers will go on quietly improving it and giving the users the benefit of their knowledge with every bar they send out. Only they pray to be delivered from rumors of revolutions and sensations which disturb the market and work them ill rather than good.—The Engineer.

INSTALLATION OF BOILERS.

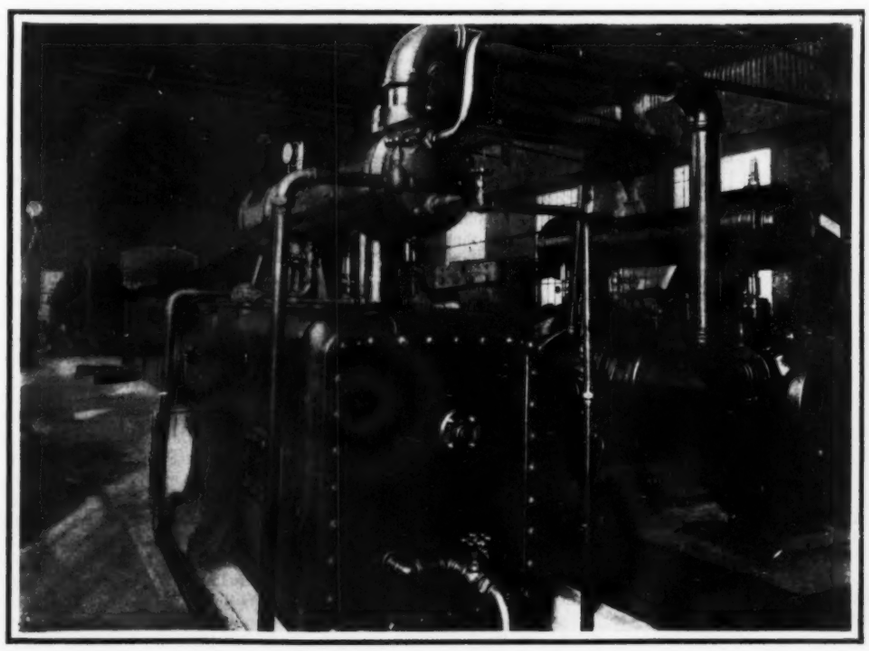
AN explosion of a return tubular boiler in an eastern manufacturing plant in the early part of this month, whereby ten men were killed, calls attention to some things about the manner of boiler installation and boiler attendance which are worthy of occasional reflection. The conditions under which this boiler was used are duplicated in many railroad shops. The boiler was placed over the metal heating furnaces in such a manner as to utilize the heat therefrom in making part of the steam used by the hammers, and for heating, etc., in the shop. Such boilers are usually connected into the main steam lines supplied by the boilers in the power plant. These conditions are liable to lead to carelessness in the operation of the isolated boilers. The water tenders and engineers of the power plant cannot look after them and men with other duties about the shop are detailed to look after the water level. The amount of steam generated depends, of course, upon the heat of the furnace below; this in turn depends upon the class of work being done by the forges. While the boiler is cut into the main steam line, its pressure cannot be raised above that of the power plant boilers, but the principal thing to be concerned about is the fact that these boilers are sometimes temporarily run independently for miscellaneous reasons. This was the case with the boiler which exploded. It developed that there was no steam gage installed and it was said that the safety valve had blown only once in eighteen years. In addition to this the boiler was an old one, having been purchased second hand at the time it was installed eighteen years ago, whereas, in such a place, only a boiler in first-class condition should have been used. The condition of the boiler



CROSS SECTION GIVING DIMENSIONS OF TUNNEL.

was clearly shown by the fragments of the shell which were picked up within a radius of a block and a half. These fragments showed blisters and a deplorable state of corrosion. It goes without saying that boilers over the forges should be subjected to the same rigid inspection as are the boilers in the main power plant, and if liable to be used independently, they should be equipped with steam gages. Most important of all, the man who is detailed to attend the water level should be the most reliable man employed in that part of the shop.—Railway and Engineering Review.

In the Engineering Review, London, Mr. F. A. Lart states that by passing an electric current of very moderate potential, as from any ordinary dry or wet electro-chemical primary battery, through the structure of a working steam boiler *via* the water contained in it and in process of conversion into steam, the formation of scale on the heating and general internal water-covered surfaces of the boiler may be entirely prevented, the deposition of the solid matters contained in the water in mechanical suspension and the precipitation of these in chemical solution being accelerated, the resulting deposit or precipitate being simply loose particles or mud of the lime, magnesia, or other impurities contained in the natural water. Mr. Lart's experiments were carried out somewhat crudely, and he therefore suggests that a thorough set of experiments be instituted for the purpose of obtaining conclusive results, as well as useful information as to the efficiency and practical utility of the method.



COMPRESSOR ROOM IN THE TUNNEL PLANT.

JOINING SIMPLON WITH LOETSCHBERG.

THE ETHER OF SPACE.*

A PHYSICAL CONCEPTION.

BY SIR OLIVER LODGE.

THIRTY years ago Clerk Maxwell gave in this place a remarkable address on "Action at a Distance." It is reported in the Journal of the Institution, vol. vii., and to it I would direct attention. Most natural philosophers hold, and have held, that action at a distance across empty space is impossible; in other words, that matter cannot act where it is not, but only where it is. The question, "Where is it?" is a further question that may demand attention and require more than a superficial answer. For it can be argued on the hydrodynamic or vortex theory of matter, as well as on the electrical theory, that every atom of matter has a universal, though nearly infinitesimal prevalence, and extends everywhere, since there is no definite sharp boundary or limiting periphery to the region disturbed by its existence. The lines of force of an isolated electric charge extend through illimitable space; and though a charge of opposite sign will curve and concentrate them, yet it is possible to deal with both charges, by the method of superposition, as if they each existed separately without the other. In that case, therefore, however far they reach, such nuclei clearly exert no "action at a distance" in the technical sense.

Some philosophers have reason to suppose that mind can act directly on mind without intervening mechanism, and sometimes that has been spoken of as genuine action at a distance; but, in the first place, no proper conception or physical model can be made of such a process, nor is it clear that space and distance have any particular meaning in the region of psychology. The links between mind and mind may be something quite other than physical proximity, and in denying action at a distance across empty space I am not denying telepathy or other activities of a non-physical kind; for although brain disturbance is certainly physical and is an essential concomitant of mental action, whether of the sending or receiving variety, yet we know from the case of heat that a material movement can be excited in one place at the expense of corresponding movement in another, without any similar kind of transmission or material connection between the two places; the thing that travels across vacuum is not heat.

In all cases where physical motion is involved, however, I would have a medium sought for; it may not be matter, but it must be something; there must be a connecting link of some kind, or the transference cannot occur. There can be no attraction across really empty space; and even when a material link exists, so that the connection is obvious, the explanation is not complete, for when the mechanism of attraction is understood it will be found that a body really only moves because it is pushed by something from behind. The essential force in nature is the *vis a tergo*. So when we have found the "traces," or discovered the connecting thread, we still run up against the word "cohesion," and ought to be exercised in our minds as to its ultimate meaning. Why the whole of a rod should follow, when one end is pulled, is a matter requiring explanation; and the only explanation that can be given involves, in some form or other, a continuous medium connecting the discrete and separated particles or atoms of matter.

When a steel spring is bent or distorted, what is it that is really strained? Not the atoms—the atoms are only displaced; it is the connecting links that are strained—the connecting medium—the ether. Distortion of a spring is really distortion of the ether. All stress exists in the ether. Matter can only be moved. Contact does not exist between the atoms of matter as we know them; it is doubtful if a piece of matter ever touches another piece, any more than a comet touches the sun when it appears to rebound from it; but the atoms are connected, as the comet and the sun are connected, by a continuous *plenum* without break or discontinuity of any kind. Matter acts on matter only through the ether. But whether matter is a thing utterly distinct and separate from the ether, or whether it is a specifically modified portion of it—modified in such a way as to be susceptible of locomotion, and yet continuous with all the rest of the ether, which can be said to extend everywhere—far beyond the bounds of the modified and tangible portion—are questions demanding, and I may say in process of receiving, answers.

Every such answer involves some view of the universal and possibly infinite uniform omnipresent connecting medium, the ether of space.

* Abstract of discourse delivered at the Royal Institution,

It has been said, somewhat sarcastically, that the ether was made in England. The statement is only an exaggeration of the truth. I might even urge that it has been largely constructed in the Royal Institution, for I will remind you now of the chief lines of evidence on which its existence is believed in, and our knowledge of it is based. First of all, Newton recognized the need of a medium for explaining gravitation. In his "Optical Queries" he shows that if the pressure of this medium is less in the neighborhood of dense bodies than at great distances from them, dense bodies will be driven toward each other, and that if the diminution of pressure is inversely as the distance from the dense body, the law will be that of gravitation.

All that is required, therefore, to explain gravity is a diminution of pressure, or increase of tension, caused by the formation of a matter unit—that is to say, of an electron or corpuscle; and although we do not yet know what an electron is—whether it be a strain center, or what kind of singularity in the ether it may be—there is no difficulty in supposing that a slight, almost infinitesimal strain or attempted rarefaction should be produced in the ether whenever an electron came into being, to be relaxed again only on its resolution and destruction. Strictly speaking, it is not a real *strain*, but only a "stress," since there can be no actual *yield*, but only a pull or tension, extending in all directions toward infinity.

The tension required per unit of matter is almost ludicrously small, and yet in the aggregate, near such a body as a planet, it becomes enormous.

The force with which the moon is held in its orbit would be great enough to tear asunder a steel rod four hundred miles thick, with a tenacity of thirty tons per square inch, so that if the moon and earth were connected by steel instead of by gravity, a forest of pillars would be necessary to whirl the system once a month round their common center of gravity. Such a force necessarily implies enormous tension or pressure in the medium. Maxwell calculates that the gravitational stress near the earth, which we must suppose to exist in the invisible medium, is 3,000 times greater than what the strongest steel could stand, and near the sun it should be 2,500 times as great as that.

The question has arisen in my mind whether, if the whole sensible universe—estimated by Lord Kelvin as equivalent to about a thousand million suns—were all concentrated in one body of specifiable density,* the stress would not be so great as to produce a tendency toward ethereal disruption, which would result in a disintegrating explosion and a scattering of the particles once more as an enormous nebula and other fragments into the depths of space; for the tension would be a maximum in the interior of such a mass, and, if it rose to the value 10^{23} dynes per square centimeter, something would have to happen. I do not suppose that this can be the reason, but one would think there must be *some* reason for the scattered condition of gravitative matter.

Too little is known, however, about the mechanism of gravitation to enable us to adduce it as the strongest argument in support of the existence of an ether. The oldest valid and conclusive requisition of an ethereal medium depends on the wave theory of light, one of the founders of which was your professor of natural philosophy at the beginning of last century, Dr. Thomas Young.

No ordinary matter is capable of transmitting the undulations or tremors that we call light. The speed at which they go, the kind of undulation, and the facility with which they go through vacuum forbid this.

So clearly and universally has it been perceived that waves must be waves of something—something distinct from ordinary matter—that Lord Salisbury, in his presidential address to the British Association at Oxford, criticised the ether as little more than a nominative case to the verb to undulate. It is truly *that*, though it is also truly more than that; but to illustrate that luminiferous aspect of it, I will quote a paragraph from that lecture of Clerk Maxwell's to which I have already alluded:

"The vast interplanetary and interstellar regions will no longer be regarded as waste places in the universe, which the Creator has not seen fit to fill with the symbols of the manifold order of His kingdom. We shall find them to be already full of this wonderful medium; so full, that no human power can remove it from the smallest portion of space, or produce the slightest flaw in its infinite continuity. It extends unbroken from star to star; and when a molecule of hydrogen vibrates in the Dogstar, the medium receives the impulses of these vibrations, and after carrying them in its immense bosom for several years, delivers them, in due course, regular order, and full tale, into the spectroscope of Mr. Huggins, at Tulse Hill." (It is pleasant to remember that those veteran investigators, Sir William and Lady Huggins, are still at work.)

This will suffice to emphasize the fact that the eye is truly an ethereal sense-organ—the only one which we possess, the only mode by which the ether is enabled to appeal to us, and that the detection of tremors in this medium—the perception of the direction in which they go, and some inference as to the quality of the object which has emitted them—cover all that we mean by "sight" and "seeing."

I pass, then, to another function, the electric and magnetic phenomena displayed by the ether, and on this I will only permit myself a very short quotation from the writings of Faraday, whose whole life may be said to have been directed toward a better understanding of these ethereous phenomena. Indeed, the statue in your entrance hall may be considered as the statue of the discoverer of the electric and magnetic properties of the ether of space.

Faraday conjectured that the same medium which is concerned in the propagation of light might also be the agent in electromagnetic phenomena. "For my own part," he says, "considering the relation of vacuum to the magnetic force, and the general character of magnetic phenomena external to the magnet, I am much more inclined to the notion that in the transmission of the force there is such an action, external to the magnet, than that the effects are merely attraction and repulsion at a distance. Such an action may be a function of the ether; for it is not unlikely that, if there be an ether, it should have other uses than simply the conveyance of radiation."

This conjecture has been simply strengthened by subsequent investigations.

One more function is now being discovered; the ether is being found to constitute matter—an immensely interesting topic, on which there are many active workers at the present time. I will make a brief quotation from your present professor of natural philosophy (J. J. Thomson), where he summarizes the conclusion which we all see looming before us, though it has not yet been completely attained, and would not by all be similarly expressed:

"The *whole* mass of any body is just the mass of ether surrounding the body which is carried along by the Faraday tubes associated with the atoms of the body. In fact, all mass is mass of the ether: all momentum, momentum of the ether; and all kinetic energy, kinetic energy of the ether. This view, it should be said, requires the density of the ether to be immensely greater than that of any known substance."

Yes, far denser—so dense that matter by comparison is like gossamer, or a filmy, imperceptible mist, or a Milky Way. Not unreal or unimportant—a cobweb is not unreal, nor to certain creatures is it unimportant, but it cannot be said to be massive or dense; and matter, even platinum, is not dense when compared with the ether. Not until last year, however, did I realize what the density of the ether must really be,* compared with that modification of it which appeals to our senses as matter, and which for that reason engrosses our attention. If I have time I will return to that before I have finished.

Is there any other function possessed by the ether which, though not yet discovered, may lie within the bounds of possibility for future discovery? I believe there is, but it is too speculative to refer to, beyond saying that it has been urged as probable by the authors of "The Unseen Universe," and has been thus tentatively referred to by Clerk Maxwell:

"Whether this vast homogeneous expanse of isotropic matter is fitted not only to be a medium of physical interaction between distant bodies, and to fulfill other physical functions of which, perhaps, we have as yet no conception, but also . . . to constitute the material organism of beings exercising functions of life and mind as high or higher than ours are at present—is a question far transcending the limits of physical speculation."

* On doing the arithmetic, however, I find the necessary concentration absurdly great, showing that such a mass is quite insufficient.

* See Lodge, Phil. Mag., April, 1907.

And there, for the present, I leave that aspect of the subject.

I shall now attempt to illustrate some relations between ether and matter.

The question is often asked, Is ether material? This is largely a question of words and convenience. Undoubtedly the ether belongs to the material or physical universe, but it is not ordinary matter. I should prefer to say it is not "matter" at all. It may be the substance or substratum or material of which matter is composed, but it would be confusing and inconvenient not to be able to discriminate between matter, on the one hand, and ether on the other. If you tie a knot on a bit of string, the knot is composed of string, but the string is not composed of knots. If you have a smoke or vortex ring in the air, the vortex-ring is made of air, but the atmosphere is not a vortex-ring, and it would be only confusing to say that it was.

The essential distinction between matter and ether is that matter *moves*, in the sense that it has the property of locomotion and can effect impact and bombardment, while ether is *strained*, and has the property of exerting stress and recoil. All potential energy exists in the ether. It may vibrate, and it may rotate, but as regards locomotion it is stationary—the most stationary body we know—absolutely stationary, so to speak; our standard of rest.

All that we ourselves can effect, in the material universe, is to alter the motion and configuration of masses of matter; we can move matter by our muscles and that is all we can do directly; everything else is indirect.

But now comes the question, How is it possible for matter to be composed of ether? How is it possible for a solid to be made out of fluid? A solid possesses the properties of rigidity, impenetrability, elasticity, and such like; how can these be imitated by a perfect fluid such as the ether must be? The answer is, they can be imitated by a fluid in motion, a statement which we make with confidence as the result of a great part of Lord Kelvin's work.

It may be illustrated by a few experiments.

A wheel of spokes, transparent or permeable when stationary, becomes opaque when revolving, so that a ball thrown against it does not go through, but rebounds. The motion only affects permeability to matter; transparency to light is unaffected, until something near the speed of light itself is reached.

A silk cord hanging from a pulley becomes rigid and viscous when put into rapid motion, and pulses or waves which may be generated on the cord travel along with it a speed equal to its own velocity, whatever that velocity may be, so that they appear to stand still. This is a case of kinetic rigidity, and the fact that the wave-transmission velocity is equal to the rotatory speed of the material is typical and important, for in all cases of kinetic elasticity these two velocities are of the same order of magnitude.

A flexible chain, set spinning, can stand up on end while the motion continues.

A jet of water at sufficient speed can be struck with a hammer, and resists being cut with a sword.

A spinning disk of paper becomes elastic, like flexible metal, and can act like a circular saw. Sir William White tells me that in naval construction steel plates are cut by a rapidly revolving disk of soft iron.

A vortex-ring, ejected from an elliptical orifice, oscillates about the stable circular form, as an India-rubber ring would do, thus furnishing a beautiful example of kinetic elasticity, and showing us clearly a fluid displaying some of the properties of a solid.

A still further example is Lord Kelvin's model of a spring balance, made of nothing but rigid bodies in spinning motion.*

If the ether can be set spinning, therefore, we may have some hope of making it imitate the properties of matter, or even of constructing matter by its aid. But how are we to spin the ether? Matter alone seems to have no grip of it. I have spun steel disks, a yard in diameter, 4,000 times a minute, have sent light round and round between them, and tested carefully for the slightest effect of the ether. Not the slightest effect was perceptible. We cannot spin ether mechanically.

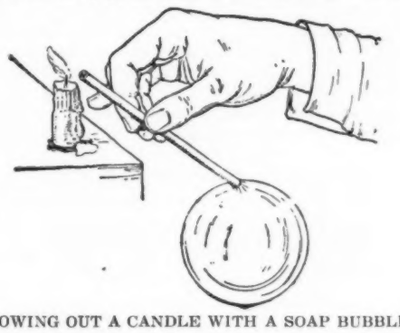
But we can vibrate it electrically, and every source of radiation does that. An electrified body, in sufficiently rapid vibration, is the only source of ether-waves that we know, and if an electric charge is suddenly stopped it generates the pulses known as X-rays, as the result of the collision. Not speed, but sudden change of speed, is the necessary condition for generating waves in the ether by electricity.

We can also infer some kind of rotary motion in the ether, though we have no such obvious means of detecting the spin as is furnished by vision for detecting some kinds of vibration. It is supposed to exist whenever we put a charge into the neighborhood of a magnetic pole. Round the line joining the two the ether is spinning like a top. I do not say it is spinning fast: that is a question of its density; it is, in fact, spinning with excessive slowness, but it is spinning with a definite moment of momentum. J. J. Thomson's theory makes its moment of momentum exactly equal to em, the product of charge and pole, the charge being measured electrostatically and the pole magnetically.

How can this be shown experimentally? Suppose we had a spinning top inclosed in a case, so that the spin was unrecognizable by ordinary means—it could be detected by its gyrostatic behavior to force. If allowed to "precess" it will respond by moving perpendicularly to a deflecting force. So it is with the charge and the magnetic pole. Try to move the charge suddenly, and it immediately sets off at right angles. A moving charge is a current, and the pole and the current try to revolve round one another—a true gyrostatic action due to the otherwise unrecognizable ethereal spin. The fact of such magnetic rotation was discovered by Faraday.

I know that it is usually worked out in another way, in terms of lines of force and the rest of the circuit; but I am thinking of a current as a stream of projected charges, and no one way of regarding such a matter is likely to exhaust the truth or to exclude other modes which are equally valid. Anyhow, in whatever way it is regarded, it is an example of the three rectangular vectors.

The three vectors at right angles to each other, which may be labeled current, magnetism, and motion, respectively, or more generally E. H. and V, represent the quite fundamental relation between ether and matter, and constitute the link between electricity, magnetism, and mechanics. Where any two of these are present, the third is a necessary consequence. This principle is the basis of all dynamos, of electric motors, of light, of telegraphy, and of most other things. Indeed, it is a question whether it does not underlie everything that we know in the whole of the physical sciences, and whether it is not the basis of our conception of the three dimensions of space.



BLOWING OUT A CANDLE WITH A SOAP BUBBLE.

Lastly, we have the fundamental property of matter called inertia, which, if I had time, I would show could be explained electromagnetically, provided the ethereal density is granted as of the order 10^{12} grammes per cubic centimeter. The elasticity of the ether would then have to be of the order 10^{33} C.G.S., and if this is due to intrinsic turbulence, the speed of the whirling or rotational elasticity must be of the same order as the velocity of light. This follows hydrodynamically, in the same sort of way as the speed at which a pulse travels on a flexible running endless cord, the tension of which is entirely due to the centrifugal force of the motion, is precisely equal to the velocity of the cord itself; and so, on our present view, the intrinsic energy of constitution of the ether is incredibly and portentously great, every cubic millimeter of space possessing what, if it were matter, would be a mass of a thousand tons, and an energy equivalent to the output of a million-horse-power station for forty million years.

The universe we are living in is an extraordinary one, and our investigation of it has only just begun. We know that matter has a psychical significance, since it can constitute *brain*, which links together the physical and the psychical worlds. If anyone thinks that ether, with all its massiveness and energy, has probably no psychical significance, I find myself unable to agree with him.

* Address to Section A of British Association at Montreal, 1884.

BLOWING OUT A CANDLE WITH A SOAP BUBBLE.

A SOAP bubble is a very good example of the phenomenon of surface tension. With pure water a permanent bubble cannot be blown, because the surface tension of the water is smaller than the air pressure within the bubble. By dissolving soap shavings in the water, the surface tension is increased. Glycerine soap gives the best results.

With a little practice it is possible to make use of the pressure in a soap bubble to blow out a small candle. Some difficulty may be met with at first, because the bubble closes up at the mouth of the tube on which it is blown. This always happens if the bubble hangs down from the tube. For this reason a straw is better adapted for the experiment than a glass tube. If the straw is split at the end, and the split portions are bent at a right angle, it is easy to keep the bubble at right angles to the straw, a condition which is necessary for success.

To perform the experiment, blow a bubble about the size of a walnut, and, by allowing the air from the bubble to be forced back into the mouth, ascertain that the bubble is open and actually does tend to blow out the air contained. After two or three such trials, blow the bubble up once more, and withdraw the straw from the mouth, quickly closing off the straw with the thumb. Without delay bring the end of the straw near the candle flame, and on withdrawing the thumb from the end of the straw, so as to allow the air to escape, the issuing current of air may be made to extinguish the candle with a little dexterity.

The experiment is most easily carried out if instead of a straw a funnel is used for producing the bubble. In that case the bubble can assume quite large dimensions.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Kosmos.

COMPARATIVE TESTS OF DENATURED ALCOHOL.

IN connection with the international exhibition for the utilization of alcohol and the fermentation industries, held in Vienna last year, comparative experiments on denatured alcohol were performed by the French section of the exhibition. A record of these tests, conducted by Mr. L. Périssé, appeared in a recent issue of the Zeitschrift des Vereins deutscher Ingenieure.

Of the alcohol motors exhibited by French firms, a 10-horse-power motor of the Gobron-Brillié system was chosen, as its cylinder dimensions, and especially the large ratio between the stroke and diameter, made it especially suitable for alcohol operation. The twin motor is 85 millimeters in cylinder diameter and 156 millimeters in stroke, of which 68 millimeters correspond to the upper and 88 millimeters to the lower piston, the cylinder ratio thus being 1.9. The two cranks are set at an angle of 180 degrees. The average number of revolutions per minute is 1,200. In the place of the well-known Gobron-Brillié sprinkling carbureter with conic nozzle, the motor was fitted with a Longuemarre carbureter, heated by exhaust gases and which was especially suitable for alcohol. Three tin tanks, one of which was filled either with pure benzol or with a mixture of equal parts of alcohol and benzol, serving to start the motor and to heat its various parts during the first ten minutes, were connected to the carbureter through a three-way cock, thus avoiding the impurities in the motor due to precipitation. The second tank contained the alcohol to be used as basis for comparison with the alcohol to be tested and which was contained in the third tank. After the motor has been preheated the reservoir No. 2 was connected to the carbureter, and the latter so regulated that the exhaust gases did not show any traces of unburned fuel. In order fully to ascertain the right operation of the motor, the latter was examined by means of a Methot indicator, after which the reservoir No. 3, containing the alcohol to be tested, was connected up and the motor examined as to its output and speed. After the completion of each experiment, the driving alcohol from the first reservoir was connected before stopping the motor. A Ch. Renard vane dynamometer was used to determine the output of the motor. The following table contains some records of the substances used to denaturate the alcohol in various countries and are partly results of chemical analysis, as the denaturating processes themselves are kept secret in many countries:

Kind of Alcohol and Designation.	Specific Weight at 15 Deg. C.	Methylene and Its Impurities, Per Cent.	Pyridine or Pyridine Bases, Per Cent.	Acetone, Per Cent.	Benzol, Per Cent.	Benzine (Impure), Per Cent.
France	0.832	7.5		2.5		0.5
Germany (denatured)	0.819	1.5	0.5	0.5	.....	.....
Germany (motor alcohol)	0.825	0.75	0.25	0.25	2.0	.....
Austria (denatured)	0.835	3.75	0.5	1.25	.....	.....
Austria (motor alcohol)	0.826	0.5	trace	trace	2.5	.....
Russia	0.836	10.0	0.5	5.0	.....	.....
Italy (motor alcohol)	0.835	6.5	0.65	2.0	1.0	.....
Switzerland	0.837	5.0	0.32	2.2	.....	.....

The following are maximum outputs and consumptions:

	Output, Horse Power.	Consumption, g/H. P. Hour.
France	9.75	932
Germany (motor alcoh.)	11.7	835
Austria	10.9	747
Russia	10.5	984
Italy (motor alcoh.)	10.0	931
Switzerland	9.8	1,084

From a comparison of these results with analyses of the fuel, the favorable influence of benzol additions is inferred, though this be limited by the necessity of reducing the smell of the exhaust.

THE WALSCHAERT VALVE GEAR.*

AN OLD INVENTION WITH A MODERN HISTORY.

BY C. O. ROGERS.

The Walschaert valve gear, though but lately introduced on any large scale in American locomotive practice, is as old a device as the Stephenson shifting link motion, with which every engineer is familiar. In 1844 Egide Walschaerts, at that time chief shop superintendent of the Brussels Southern Rail-

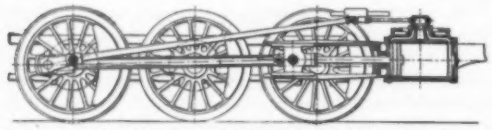


Fig. 1.—SIMPLEST FORM OF VALVE MOTION.

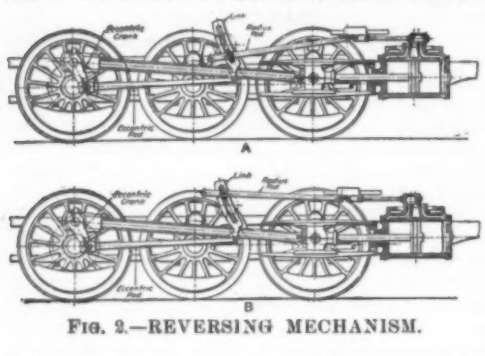


Fig. 2.—REVERSING MECHANISM.

road, invented the type of valve motion which bears his name. Because of the fact that the rules of the railway company did not allow a foreman in the shops to advertise a patent in Belgium to his own profit, the application for the patent was made by M. Fischer, engineer of the State Railways of Brussels, a friend of Walschaerts,' in the latter's name. The patent was granted by royal decree on November 30th, 1844, and the mechanism described in the patent resembles the motion which is now in use on many American locomotives. The so-called Stephenson shifting link motion came into prominence a year earlier, or in 1843. The Walschaert valve gear attracted a great deal of attention in Europe and gradually became the accepted type of valve motion on the railroads of continental Europe, just as the Stephenson link motion came into general use on American railroads.

Although there are a number of special cases in which the Walschaert valve gear has been applied to locomotives in this country as far back as 20 or 25 years ago, it is only during the last few years that it has been used in America on any large scale. With the increase in power and weight of the modern locomotive, however, conditions have arisen to meet which the American designer has turned to the Walschaert valve gear because it offers certain mechanical and structural advantages over the Stephenson motion.

Because of the increase in size of the parts, there is hardly room enough between the frames of a modern heavy freight or passenger engine for the accommodation of the Stephenson gear. The eccentrics are crowded together so that it is almost impossible for the engineer to give them proper inspection or lubri-

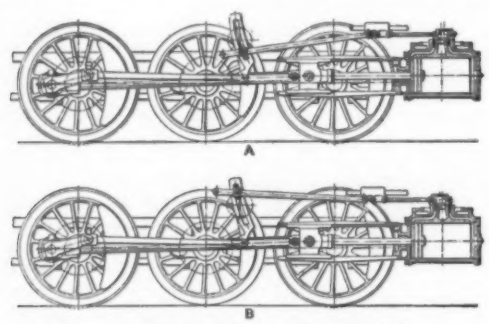


Fig. 3.—LINK BLOCK POSITIONS.

cation. The Walschaert valve gear, on the contrary, being outside of the frames, is perfectly accessible, and can therefore be much more easily maintained.

With the high surface velocities of the largest sizes of eccentrics, it is difficult to keep them properly lubricated. With the Walschaert valve gear, there are no large eccentrics to keep lubricated; but with hardened pins and hardened bushings it has an important advantage in maintenance.

* A paper read before the Eleventh Biennial Convention, Brotherhood of Locomotive Firemen and Enginemen.

The Walschaert gear transmits the moving force to the valve in very nearly straight lines, so that there is less springing and yielding of the parts than in the Stephenson link motion.

The Stephenson link, under the influence of two eccentrics, moves through wide angles, resulting in a wedging action of the link block which strains the gear and produces lost motion. The Walschaert link, driven by a single eccentric, moves through smaller angles and produces less lost motion.

By removing the valve gear from between the frames, as we do in the case of the Walschaert gear, a better opportunity is afforded to introduce stronger frame bracing, and thus reduce the possibility of frame failures.

The Walschaert valve gear shows a distinct advantage over the Stephenson link motion as regards permanence of adjustment. When a large freight engine is half way between shoppings the Stephenson link motion is slack and loose, while the Walschaert valve gear is in as nearly good condition as when the engine left the shop; consequently the original steam distribution is much better maintained with the Walschaert than with the Stephenson motion.

These are some of the reasons why a large number of American railroads are now equipping their engines with the Walschaert valve gear. Seldom in the history of the development of the locomotive in this country has any improvement, once introduced, been so rapidly accepted as this type of valve motion; and, inasmuch as its use will undoubtedly increase, a clear understanding of its principles and construction is essential.

The best place to begin is always at the beginning; and as the Walschaert valve motion, like any other

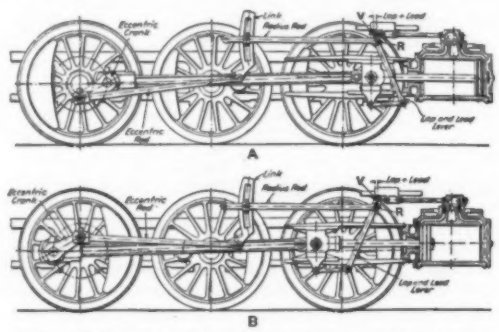


Fig. 4.—INTRODUCTION OF THE LAP AND LEAD LEVER.

device, is merely a development of some simpler form, it is necessary in studying it to start with the original form and trace the various steps in the development.

Fig. 1. represents the simplest form of valve motion; viz., a single eccentric of the return crank

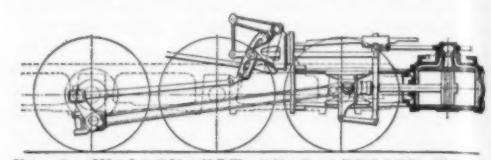


Fig. 5.—WALSCHAERT GEAR APPLIED TO A CONSOLIDATION ENGINE.

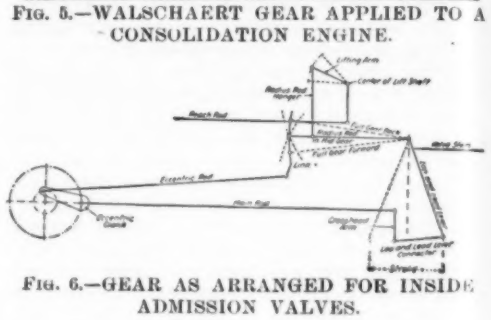


Fig. 6.—GEAR AS ARRANGED FOR INSIDE ADMISSION VALVES.

motive, the valve of the left-hand engine would be in a position to admit steam behind the piston and start the wheels turning to the right. The eccentric crank on the engine which is shown would then move the valve forward, uncovering the back steam port and admitting steam behind the piston, and the engine would run forward. It is perfectly evident, however, that this engine will only run in one direction; for if, to start it backward, the wheel were pinched to the left, with the eccentric in the position as shown, the valve would be moved to the left and steam admitted ahead of the piston, forcing the crank pin back again to its position on the back center. In order to make the engine run backward, the eccentric would have to be a quarter of a revolution ahead of the main pin and move the valve forward, opening up the back port and admitting steam behind the piston as is necessary.

The first thing to do in the development of this simple form of engine, therefore, is to introduce some means by which it can be reversed. This can be accomplished by introducing a beam between the eccentric and the valve stem, pivoted at its center so that one end moves with and in the same direction as the eccentric and the other end in exactly the opposite direction.

Such a construction is shown in Fig. 2. With the valve stem at the lower end of the link and the main pin on the upper quarter, as shown in diagram A,

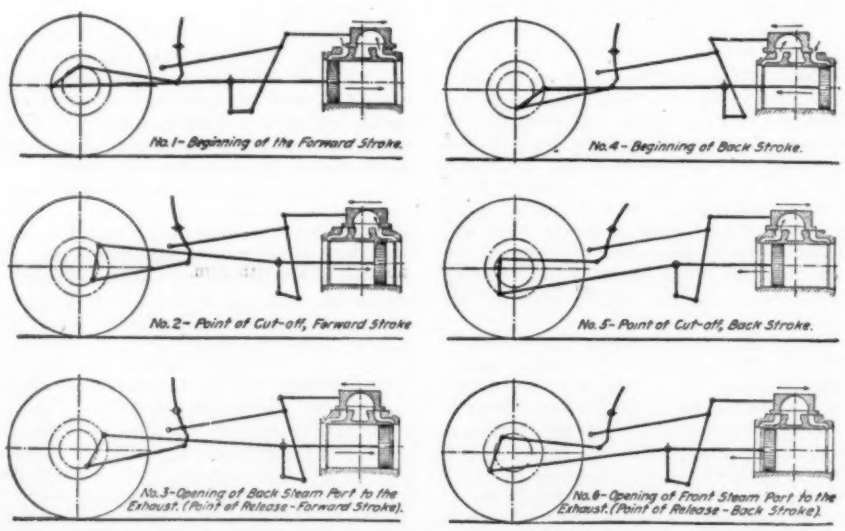

No. 1- Beginning of the Forward Stroke.
No. 4- Beginning of Back Stroke.
No. 2- Point of Cut-off, Forward Stroke
No. 5- Point of Cut-off, Back Stroke.
No. 3- Opening of Back Steam Port to the Exhaust. (Point of Release - Forward Stroke).
No. 6- Opening of Front Steam Port to the Exhaust. (Point of Release - Back Stroke).

Fig. 7.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

form, driving a plain normal valve without lap or lead by means of an eccentric rod directly connected to the valve stem. Assuming that the engine is to run forward, with the main pin on the back center, as shown, the eccentric crank pin must be on the top

the eccentric will have moved the valve to its extreme forward position and the back port will be opened for the admission of steam behind the piston and the engine will run forward. If, however, with the main pin and eccentric crank in the same position,

the valve stem were connected to the upper end of the link, as shown in diagram B, the valve would be moved to its extreme position to the left and the front port would be opened and steam admitted ahead of the piston, and the engine would run backward. With a flexible valve stem, or radius rod, connected to a block which slides in a curved slot in the beam, or link, as shown, and with the necessary mechanism for raising and lowering the block, it is evident that we now have an engine that can be reversed.

This engine, however, is still far from an efficient machine; for, as the valve does not close the port for the admission of steam until it is in its central position on the seat; and, as with the eccentric only a quarter of a revolution ahead of the main pin, it is not in this position until the main pin is on the center, whatever the travel of the valve, steam will be admitted to the cylinders throughout the full stroke of the piston, and the engine will use as much steam working against a light as against a heavy load. In order to govern the period for the admission of steam, or, in other words, give a variable cut-off, the valve must be redesigned so that it will close the steam port before it reaches its central position; that is, it must be given "lap," the lap of a valve being that portion of it which overlaps the steam ports when it is on its central position on the seat. But with lap given to the valve and also "lead," which is the width of the opening of the steam port given by the valve when the piston is at the beginning of its stroke, the valve motion must be so changed that the valve will be advanced from its central position on the seat a distance equal to the amount of the lap plus the lead, when the crank pin is on either of the centers.

It is apparent, from an examination of Fig. 3, that this advance of the valve can not be obtained by any change in the position of the eccentric crank relative to the main pin. Fig. 3 shows the same valve motion as was shown in Fig. 2, except that the valve has one

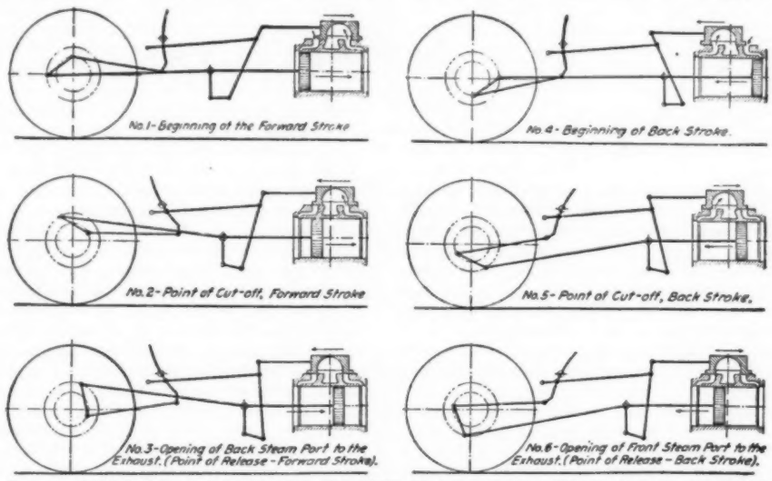

No. 1- Beginning of the Forward Stroke
No. 4- Beginning of Back Stroke.
No. 2- Point of Cut-off, Forward Stroke.
No. 5- Point of Cut-off, Back Stroke.
No. 3- Opening of Back Steam Port to the Exhaust. (Point of Release - Forward Stroke).
No. 6- Opening of Front Steam Port to the Exhaust. (Point of Release - Back Stroke).

FIG. 8.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

inch outside lap and the eccentric crank has been advanced to more than a quarter of a revolution ahead of the main pin. If then the link block is at the bottom of the link, as in position A, the advance given to the eccentric will have moved the valve forward a distance equal to the lap plus the lead, and the back port will be opened for the admission of steam and the engine will run forward. If, on the other hand, the link block is moved to the upper end of the link, as shown in position B, the advance given to the eccentric crank will have had the opposite effect and the front port will be opened and the reversibility of the engine thus destroyed. In order to provide lead, therefore, in any engine where there is but one eccentric, some means must be employed other than advancing or receding the position of that eccentric relative to the main pin, if there is to be any method of reversing the engine.

In the Walschaert valve gear the motion for providing lap and lead to the valve is derived from the main pin by suitable connections with the crosshead.

This brings us to the next step in the development of the Walschaert valve gear and the introduction of the lap and lead lever. Suppose that our link block is in the center of the link as shown in position *A*, Fig. 4. As the center of the link block coincides with the center of the link support, there will be no movement of the radius rod as the link swings back and forth through the action of the eccentric. If, then, the radius rod were connected with the lap and lead lever at the point *R*, and the upper end of the lever was connected to the valve stem crosshead at *V*, and the lower end to the crosshead arm by means of a short link, as shown, as this latter moves back and forth, the point *R* being fixed, the point *V* will rotate about it and the valve will be moved back and forth. With the main pin on the forward center, as shown in position *A*, the angle assumed by the lap and lead lever has moved the valve back a sufficient distance to uncover the front port. With the main pin on the back center, as shown in position *B*, the lap and lead lever is inclined in the opposite direction and the valve moved forward, and the back port is open. This is the way the Walschaert valve gear derives its lead. The distances between the connecting points of the lap and lead lever must be so proportioned that the travel of the crosshead from one end of the stroke to the other will give a travel to the valve equal to twice the lap plus the lead. That this lead is permanent and does not vary as the reverse lever is hooked up will be shown later on.

The position of the eccentric crank relative to the main pin depends on which end of the link is used for forward motion. If the forward motion is taken from the bottom of the link, as is usually the case, the eccentric crank is a quarter of a revolution ahead of the main pin when the wheel is running forward, if the valves have outside admission; and a quarter of a revolution behind it, if the valves have inside admission. If the top of the link is used for forward motion, the eccentric crank is a quarter of a revolution behind the main pin, if the valves have outside admission; and a quarter of a revolution ahead of it, if the valves have inside admission. In all cases, if the valves have outside admission, the radius rod is connected to the lap and lead lever below the valve stem, and above it, if the valves have inside admission.

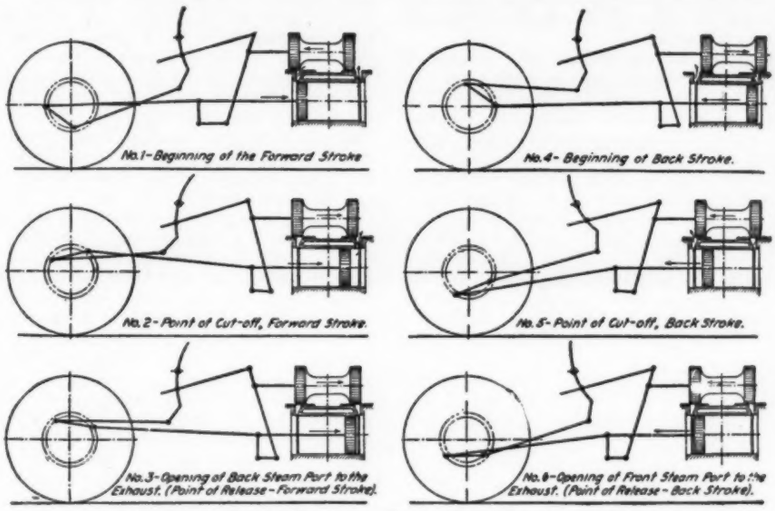

No. 1- Beginning of the Forward Stroke
No. 4- Beginning of Back Stroke.
No. 2- Point of Cut-off, Forward Stroke.
No. 5- Point of Cut-off, Back Stroke.
No. 3- Opening of Back Steam Port to the Exhaust. (Point of Release - Forward Stroke).
No. 6- Opening of Front Steam Port to the Exhaust. (Point of Release - Back Stroke).

FIG. 9.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

The simple form of direct valve motion, shown in the first figure, has now been so modified that the engine is reversible and has a variable cut-off. It only remains to provide the necessary reversing mechanism and we have the Walschaert valve gear in its complete form as shown in Fig. 5, which represents its application to a consolidation engine.

Fig. 6 shows a general outline of the gear as arranged for inside admission valves on which are given the names of the various parts as recommended by the American Railway Master Mechanics' Association. Starting at the crank pin, we have the eccentric crank, eccentric rod, link, reach rod, lift shaft, radius rod hanger, radius rod, lap and lead lever, lap and lead lever connector, and crosshead arm.

Having studied the functions of the different parts of the Walschaert valve gear, it remains to trace the movement of the valve through a complete revolution of the wheel. Figs. 7, 8, 9 and 10 show a series of diagrams representing different positions of the valve for different positions of the crank pin. For the sake of simplicity, the valve and cylinder are shown in section, while the other parts of the gear are represented by their center lines and center points only. As will be apparent, these diagrams are out of proportion, the valve and the eccentric throw having been enlarged in order to bring out more clearly the positions of the edges of the valve relative to the edges of the cylinder ports. In Fig. 7, the valve is outside admission and the motion is represented as being in full forward gear; or with the reverse lever in the

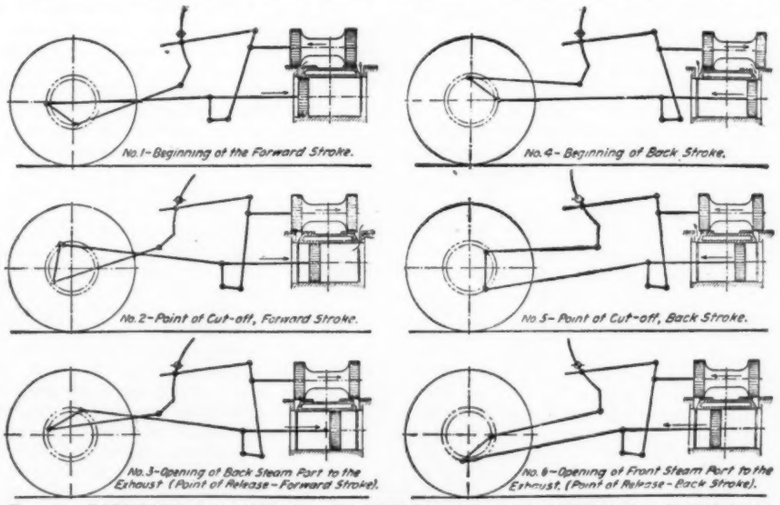

No. 1- Beginning of the Forward Stroke.
No. 4- Beginning of Back Stroke.
No. 2- Point of Cut-off, Forward Stroke.
No. 5- Point of Cut-off, Back Stroke.
No. 3- Opening of Back Steam Port to the Exhaust (Point of Release - Forward Stroke).
No. 6- Opening of Front Steam Port to the Exhaust. (Point of Release - Back Stroke).

FIG. 10.—DIFFERENT POSITIONS OF THE VALVE FOR DIFFERENT POSITIONS OF THE CRANK PIN.

extreme forward position. Fig. 8 represents the same valve motion, but in this case the reverse lever is hooked up and the link block is nearer the center of the link and the engine is cutting off at about 25 per cent of the stroke. Figs. 9 and 10 represent a valve motion as arranged for an inside admission piston valve; in Fig. 9, the motion being in full gear forward, while in Fig. 10 it is represented with the reverse lever hooked up.

As has already been shown, the valve receives its motion from two distinct sources; first, from the eccentric crank which gives the long travel to the valve; and second, from the crosshead by means of the lap and lead lever, which would give a short travel to the valve even if the eccentric rod was disconnected.

Starting with diagram 1, Fig. 7, as the valve is outside admission, with the main pin on the back center, the eccentric crank is on the top quarter, or a quarter of a revolution ahead of the pin, and the radius rod is connected to the lap and lead lever below the valve stem. The link is in its central position, and the valve would be in its central position on the seat, if it were not for the motion given to it by the lap and lead lever. As it is, however, the crosshead being at the back end of the stroke, the lower end of the lap and lead lever is at its extreme back position and the angle assumed by the lever has moved the valve forward, as indicated by the arrow, a distance equal to the lap of the valve plus the lead. Going to diagram 1, in Fig. 8, the main pin, eccentric crank and crosshead are in the same position as they were in the corresponding diagram in Fig. 7; and the link is in its central position. Thus, although the link block is near the center of the link, the radius of the link being equal to the length of the radius rod, the front end of the radius rod is the same horizontal distance from the center of the crosshead as it is in diagram 1, Fig. 7; consequently the angle assumed by the lap and lead lever is the same and the valve has been moved forward the same distance from its central position, and the lead is the same as it is with the reverse lever in full gear.

In Figs. 9 and 10, diagram 1 in each case represents the position of the valve at the beginning of the forward stroke; the same as the corresponding diagrams in Figs. 7 and 8. As the valves are inside admission, however, the radius rod is connected to the lap and lead lever above the valve stem. The valve, in each case, has thus been moved back, instead of forward, by the movement of the lap and lead lever; and the back port is open to the live steam and the front port to the exhaust.

Going back to Fig. 7, in diagram 2, the piston has moved forward a distance equal to about 85 per cent of the stroke; the valve has traveled to its extreme forward position and back again, as indicated by the arrow, till it has just closed the back steam port; while the front port is still open to the exhaust. In other words, the valve is at the point of cut-off. In diagram 3, the piston has moved still nearer to the forward end of the stroke. The exhaust edge of the valve is now in line with the edge of the back steam port; so that any further movement will open communication with this port and the exhaust. The front port, on the other hand, has been closed to the exhaust and whatever steam is ahead of the piston will be compressed. In diagram 4, the piston is at the extreme forward end of the stroke; the angle assumed by the lap and lead lever has moved the valve back a distance equal to the lap plus the lead; the front port is open for the admission of steam and the back port is open to the exhaust. In diagram 5, the piston is moving toward the back end of the cylinder and the valve has just closed the front port to the admission of steam, showing the cut-off position of the valve on the back stroke. In diagram 6, the piston is very nearly at the end of the back stroke and the valve is about to open the front port to the exhaust; while the back port is closed to the exhaust and compression is taking place in the back end of the cylinder.

As the diagrams in Figs. 8, 9 and 10 represent the same valve events as the corresponding diagrams in Fig. 7, it will not be necessary to examine them separately. It will be noticed that in Figs. 8 and 10 the valve cuts off the steam from the cylinders and opens the steam ports to the exhaust at a much earlier period in both the forward and back stroke than it does in Figs. 7 and 9, which shows the effect of hooking up the reverse lever.

These diagrams show very plainly the difference in the arrangement of the Walschaert valve gear for outside and inside admission valves, also the fact that the lead of the valve is the same for all cut-offs.

To change the lead of the Walschaert valve gear, it is necessary to either change the lap of the valve, reducing it to increase the lead and increasing it to reduce the lead, in which case the cut-offs will occur at later or earlier periods in the stroke, respectively; or to change the lengths of the arms or distances between the connecting points of the lap and lead lever. Increasing the distance between the radius rod connection and the valve stem connection to the lap and lead lever would increase the lead; or shortening this distance would decrease the lead.

THE OPTICS OF SKULKING AND SCOUTING.

THE MILITARY VALUE OF LIGHT EFFECTS.

BY W. R. GILBERT.

THE protective coloring of animals has long been a subject of much interest to naturalists. The protective effect is due to the fact that an object is rendered inconspicuous by being of the same color as its background. This is of less importance and interest than the fact that an object is least conspicuous when it harmonizes with its surroundings as a whole; and, secondly, that any object is, on the whole, least conspicuous anywhere when it is least conspicuous in itself. These last two factors are somewhat interwoven, since the ability of the eye to appreciate any color or form effect depends upon what other colors and forms come within its range at the moment, as well as upon the nature of the objects upon which it has just been focused.

One example illustrates these principles: A partridge is inconspicuous because it is, generally, of colors similar to those of the fields in which it lives; because it may, at a distance, present the appearance of any of several different objects; and because, having neither one color to strike the eye as a mass, nor any very dark or light colors over a considerable area, it is inconspicuous in itself.

The fact of similar coloring is the least important, at all events under normal autumn and winter conditions. If the bird were of one color similar to the average or distant color of a plowed field, it would strike the eye as an object not of a piece with the ground, the upper side lighter and the lower side darker; as it is, it is more like a succession of patches of varying shade and surface, and both its surface and its edges are thereby rendered less conspicuous.

Particularly at certain seasons, but to a great extent at any time, the effects of light and shade are more important in this connection than those of color. For sheer conspicuousness the effect of one color alone is often much greater than that of sharply contrasting colors, the practical limit being reached in the case of the starling, which, at any distance beyond a few yards, appears to be dark gray, so minutely are its brilliant colors divided up. On a far larger scale bright stripes, such as those of the zebra, give the impression of a neutral gray at a sufficient distance.

The effect of one color, a "self color," is not only to make an object more conspicuous in itself, but also to reduce its chances of harmonizing with its surroundings. In almost any place a magpie is far less conspicuous than a crow. Even against a dark background in shady places a dark color fares badly, since the darkness of its surroundings being due to shade, as in a wood, an object already dark becomes darker still, retaining its difference in light emission.

The coloring of lighthouses often shows the ineffectiveness of bright contrasts; for example, in passing a chalk cliff, at the foot of which is a lighthouse painted in alternate black and white, a ship's officer failed for some time to perceive the lighthouse; and it was obvious that against the cliff, with its lighter and darker portions, not only would black have been the proper color, but the lighthouse would have been more conspicuous had it been painted all white. It would then have been less like the varying surface of the cliff, and would have been more conspicuous as a detached object. Surveyors know that the usual surveying pole, in which each foot length is painted a different color, is far less easily picked up by the eye or telescope than is a pole all of one color. The danger signals erected to warn motorists furnish an illustration. On a main road leading out of London, England, two neighboring villages are protected by triangle signals. In one case the signal is conspicuous, the red triangle being mounted on a wooden post painted the same color. In the other village the signal is not effective, being mounted on a thin angle iron painted white. This dusty white support not only fails to lead the eye to the red triangle, but is itself much the same color as the wall and road which form its background and harmonizes in color and form with a lamppost a few yards away.

In a naval war a great advantage would be gained by the power which first learned to paint a warship in at least two colors or shades. The surface of a warship should be divided up into uneven, irregular patches in, say, two shades, one considerably darker and one considerably lighter than some good neutral tint. The division would be into a few large patches, not into many small ones, else they will blend at a distance, and the ship will loom as a single object. Each patch may, however, be subdivided into two or more shades of its average tint. This matter will doubtless be of much greater importance when torpedo boats and some larger vessels are propelled by gasoline engines, and leave no trail of smoke. The overhung parts of a ship and the under sides of all detached objects should be painted in the lightest tint or in white except where, in large vessels, it may be worth while to attempt to neutralize the line of whiteness made by small waves breaking against the side of the vessel. Parts exposed to the light of the sky should be painted with the darkest shades. Light beneath and dark above is the general distribution of color in the animal world, and all the cunning of man cannot do better than nature in these matters.

Although great advances have been made in rendering the soldier inconspicuous, only a few of the more obvious laws of light and vision have been considered and applied. No type of uniform should be passed for service until it has been examined by an officer who is a real specialist in the subject we are now considering.

In war it is necessary to make each individual soldier as inconspicuous as possible, even to the darkening of the upper side of his hat and the lightening of the under side of the brim, reducing the effect of shadows about his feet, taking advantage of the breaks of continuity afforded by belts and haversacks, so that against a varied background he may lose size and shape. If this be done a marksman, even when he is distinctly visible, will hit him less easily than if he were all of one color. For scouting purposes special colors suited to the country should be chosen; but generally it is worth while dividing the man up visually, not quite in the way of ordinary clothes, and the colors should be some that blend into a neutral tint at a distance. Scouts should carry a few faded rags of different colors. But the individual is not everything; the principles of protective coloring and shading should be carried out in the squad and company. It often happens in modern war that infantry is a mark for artillery at long ranges, and when a single soldier would not be. To get infantry across open country with little loss is a necessity, and much can then be gained by making the bodies of men as inconspicuous as possible. Irregular shape and ragged edges on the march may help this, but my point is that much may be done by adopting uniforms of different shades, and arranging the men so that they march, in their usual places, in irregular patches of different shades. Wagons should be treated in the same way as warships. By treating a gun similarly, darker above and lighter beneath, it will be less easy for the enemy to distinguish the caliber, and by painting it in different colors a gun may be made to appear shorter.

Care should be taken to select horses which have light under parts, and similarly colored horses should be well distributed in the troop. At considerable distances the total light effect is far more important than the color effect, and it should be remembered that some colors are reduced in intensity by mist more than others are.

A patent issued November 3rd to Otto Meyer, of Richmond, Va., has for its subject a new electrolyte for electroplating, one of the chief objects of which is to overcome the evolution of hydrogen at the cathode, which has a tendency to make the deposited metal porous or even spongy. The new process consists in employing an electrolyte comprising a solution of a chloride of a metal in alcohol, which latter may be wood or denatured grain alcohol. One way of

preparing the bath is to add one or several per cent of pure concentrated hydrochloric acid to the full strength alcohol, using the plating metal as an anode. Chloride of the plating metal is thus formed in the bath, and the process is carried out with dissolving in the bath at starting a chloride of the metal. It is stated that in this way alcohol, with the addition of a small amount of pure hydrochloric acid, forms directly, while cold and with no further additions, an excellent electrolyte for a number of metals, including gold, copper, nickel, etc. From 2½ to 3 volts are required for overcoming the resistance of the bath.

SOLAR ELECTRIC PHENOMENA.

THEIR RELATION TO TERRESTRIAL MAGNETIC PERTURBATIONS.

A LONG note, appended by M. Deslandres, director of the Meudon Observatory and president of the French Astronomical Society, to the year-book for 1907 of the Bureau des Longitudes, shows how, for decades past, scientists have pointed out the striking correlation between solar activity (manifested more especially in the neighborhood of the spots) and terrestrial magnetic disturbances. On the other hand, Prof. Hale, of Mt. Wilson Observatory, has actually demonstrated the electric nature of this activity, particularly in his magnificent discovery of the vortices in the hydrogen flocculi. Now M. Nordon, in a recent article in the Revue des Questions Scientifiques, of Brussels, gives some interesting data as to the precise relation between these solar electric phenomena and terrestrial magnetic disturbances. What follows is an abstract of his article.

Already in a memoir to the International Congress of Meteorology (1900) M. Marchand, director of the observatory of the Pic du Midi, refers to groups of faculæ, which, while they may change in form and size, often persist on the solar disk for more than a year, and at times as long as three years. Inside of these groups spots appear and disappear, and round about them are less luminous lines and areas, scarcely brighter than the rest of the disk.

Such parts of the solar disk have been called by M. Marchand "regions of solar activity." They are numerous between latitudes +40 deg. and —40 deg., and are generally separated by 90 or 180 degrees of longitude. Now observation shows that terrestrial troubles always occur when these regions of solar activity cross or pass over the principal solar meridian; and by noting, at the moment of such a passage, (a) the physical aspect of the region of solar activity, (b) the graphs representing the variations in the electric charge of sun and earth respectively, important practical inferences may be drawn.

This is not all, however. It is known from the researches of Carrington, about 1860, that the time of rotation of the spots is shorter at the solar equator than on either side of it. If therefore given centers of activity, situated at different latitudes, be at a given time on different meridians, they may, after a certain number of rotations, be found on the same meridian, and their concordant action at their simultaneous passage will be more intense. It will be necessary therefore to note the proper velocity of the region considered, together with the other elements of the problem.

But what will be the effects felt here below? The ionization of the superior layers of the atmosphere, under the influence of particularly intense ultra-violet radiations from the centers of solar activity, added to the positive induction by these active regions, will send out into space a great quantity of negative ions. A high zone of the terrestrial atmosphere will be charged with a positive potential, above the ordinary; to this superior positive charge will correspond a superior negative one on the surface of the earth, due to induction. Consequently, at every passage, a limited zone of particularly great electric activity will be produced in the atmosphere and on the surface of the globe, and this zone will travel over the earth with great velocity, the direction of which will be the resultant of the rotation of the sun, the rotation of the earth, and the translation of the earth around the sun. The velocity of this electric perturbation through the terrestrial atmosphere can be calculated *a priori*, both as to direction and to magnitude.

And what will be the consequences of this electric perturbation?

First, the strong electric attraction of the inferior layers of the atmosphere by the superior ones will produce low pressures, resulting generally in a cyclone or a storm, the violence of which will depend on the activity of the passage.

Then the electric attraction of the soil itself by the upper regions of the atmosphere may likewise produce a zone of seismic disturbances in case of a thin crust, or of one partially displaced under the influence of geological causes.

At the same time the negative charge of the earth's surface will be rapidly increased, with the result that there will often be a great and variable difference of potential between the regions that have been thus influenced and the others. Hence telluric currents and magnetic perturbations, the direction of which will depend on that of the passage.

Moreover the sudden increase of the electric charge in the upper regions of the atmosphere will provide slow or disruptive discharges in the thinner or polar regions: hence the auroras.

Finally electric storms will break wherever the atmosphere is charged with aqueous vapor or with clouds.

M. Marchand has shown that by comparing the dates of the passages of each region of solar activity over the central meridian with the curve of magnetic disturbances, the following general law will be found: Every maximum of the curve of magnetic disturbances coincides with the passage of a region of solar activity over the central meridian, and *vice versa*. In other words, whenever, in consequence of the rotation of the sun, an active region is brought opposite the earth, magnetic perturbations will be felt. Exceptions to this law are very rare.

Nor must it be forgotten that the presence of spots is not at all necessary, even for strong perturbations. Thus, in 1887, for instance, as was pointed out at the Meteorological Congress of 1900, remarkable disturbances coincided with the passage of faculæ in which there were neither spots nor pores. On the 15th of March, 1898, a very strong perturbation was noted, and although an important group of spots had crossed the central meridian on the 11th and 12th, no spot did so on the 15th. Did this impair the law? Not in the least; for precisely on the 15th an active region which had been under observation for several months passed over the central meridian.

Quite recently Fr. Cirera, director of the Ebro Observatory, inferred from numerous observations that terrestrial magnetic perturbations coincide with (a) the passage of a region of solar activity over the central meridian; (b) the apparition of an active region at the eastern limb of the sun; (c) an extraordinary increase of activity. According to him (see the Bulletin of the Astronomical Society of France for September, 1908) the importance of the influence of a center of solar activity on terrestrial magnetism will be the resultant not only of the extent of the troubled region, but also of the degree of its activity, and of its position relatively to the earth. The wording of this last condition should be carefully noted, for a given heliocentric latitude will occupy a quite different place relatively to the earth according to the position of the solar axis of rotation.

Fr. Cirera thinks—and he is a known specialist in the matter—that the combination of these elements of the problem will cover all cases.

What precedes might therefore be scientifically held, as far as general phenomena are considered; local phenomena, such as electric storms, depend also on local atmospheric conditions. Thus if electric storms easily occur in mountainous regions, where aqueous vapors and clouds abound, they will not occur in dry, level regions, such as the Sahara; notwithstanding the passage of zones of solar activity, even very intense.

By taking into consideration these local conditions it will be possible to compute with probability the periods in which storms will occur, and even to evaluate their relative intensity. Von Bezold has ascertained in Bavaria and Wurtemburg, and Marchand in the Pyrenees, that storm periods are 26 or 27 days.

Another class of terrestrial phenomena which seem to be directly due to the same causes are seismic perturbations. Now these phenomena may be divided into two categories: those that are brought about by the subsidence of considerable terrestrial masses, often starting in mountainous massifs and causing slight seismisms unaccompanied by eruptive or volcanic effects; and those that occur principally in the neighborhood of volcanoes and in regions where the earth's crust has been more displaced.

According to M. Marchand, the seismisms belonging to the first category, due to the subterranean sinking of some considerable rock mass, the first effect of which is to cause a downward movement of the soil at the epicenter, have a tendency to occur whenever a region of solar activity crosses the central meridian. As in the case of electric storms, however, solar action can produce its effect only when geological circumstances render seismisms possible. Lunar attraction and probably also the electric induction produced by the lunar globe must likewise be taken into account. This explains why some earthquakes have coincided to a remarkable degree with stormy weather or with abnormal movements of the magnetic needle.

By noting on the one hand the strong attractions (lunisolar) resulting from the coincidence of the syzygies with the lunar perigee, and on the other the passages of regions of solar activity, M. Marchand has been able to foresee different periods of seismic agitation such as those of July, 1904, as also those of recent date in Chili, Mexico, and the Vesuvius region.

The seismic disturbances which coincide with the passages are preceded by remarkable changes in the terrestrial charge, which can be noticed at great distances from the epicenter. Thus violent perturbations were observed in the terrestrial charge at Bordeaux on June 17th before the seismic agitation at Gibraltar. Similar observations were made on December 13th, 1902, previous to the earthquakes which occurred at Angers, in Brittany, and in Calabria.

It is particularly interesting to note how the dates of an extraordinary increase in the negative charge of the soil, and of quakes, correspond also with the periods of passages of solar activity.

So, then, to sum up, there is a whole series of terrestrial phenomena of graduated intensity whose cause must be sought for in the passage of regions of solar activity over the central meridian, from the violent manifestations which affect a whole hemisphere and are accompanied with cyclones, polar auroras, magnetic storms, and, when local conditions favor them, with electric storms, violent seismisms, volcanic eruptions, etc., down to the simple changes in the weather which bring along with them wind, rain, or snow. In like manner the absence of all passage would indicate a period of calm.

It is true, our present knowledge of the data of these most interesting but disconcerting problems is quite insufficient to allow us to foresee in a precise manner the dates of great meteorological disturbances, and especially of local changes in the weather; but we have already the key to these phenomena, and the day is perhaps not far distant when we shall be able to foretell them with truly scientific rigor.

In the meantime, and notwithstanding the limitations of our knowledge, it is possible to give, for a given region, interesting indications as to the probable weather for a period of two or three weeks; and this by noting the precise dates of the passages of the zones of solar activity and of the regions of calm. We can even evaluate approximately the intensity of the atmospheric perturbations which will result by taking into account the extent of these active solar regions, the age of the moon, the season, and some local circumstances such as the geographical situation of the region, the hygrometric state of the atmosphere, the pressure, the electric charge, etc.

WHITE ENAMEL.

FOR the production of white enamels it is customary to employ the chemically pure oxides of tin, zirconium, titanium, etc. Landau and Rosenzweiz substitute certain silicates, which become white at the temperature of firing, especially the silicates of glucinium and zirconium, for which they claim greater covering power and resistance to the action of heat and acids than are exhibited by the ordinary oxide enamels. The silicates are also much cheaper than the oxides, for natural silicates may be employed, after they have been freed of iron, cerium and other impurities by well-known mechanical and chemical processes.

An American patent recently issued to Willis R. Whitney describes a means for improving the operation and increasing the efficiency of arc lamps by improving the quality of the electrodes employed. The claims cover an arc light electrode formed out of a pure metal having a melting point materially higher than that or iron and yielding luminous or flaming arc, the metal having a good electrical conductivity and melting at a temperature exceeding 2,000 deg. C. The metal may be either titanium, molybdenum, tungsten, chromium, thorium, or uranium. It is stated that electrodes formed from these materials are very slowly consumed in the normal operation of the lamp, and give a luminous or flaming arc, which furnishes a very intense light of an excellent color. Such electrodes may be employed as negative electrodes in connection with non-condensing positive electrodes.

ELECTRICAL NOTES.

The railway from Berchtesgaden to Hangender Stein, in Switzerland, is now operated by electricity, energy being obtained from waterfalls. There are two 450 horse-power turbines, each driving a 1,000-volt direct-current generator. Energy is supplied to the motor cars from two trolley wires, and each car is provided with two 63 horse-power three-phase motors, with four main poles and interpoles. Still another Swiss road, from Salzburg to Berchtesgaden, will be operated by a single-phase current at 10,000 volts. A third road, from Salzburg to the frontier, will employ direct current at 800 volts.

A three-quarter mile stretch of level road lying along the seacoast between Pirano and St. Lucia is at present being fitted up for railless electric traction. A double overhead line is being erected for two-thirds of the way and a single line for the other one-third. The rolling stock consists of three motor cars and three trailers, and all the wheels are rubber-tired. The road inside the town is at present paved and outside it is macadamized, but the whole is to be asphalted in the near future. The line will deal not only with passenger traffic, but also with goods and postal business.

One of the most important electrical schemes carried out in connection with railways on the American continent is that of the St. Clair tunnel on the Grand Trunk Railroad, and here it has already been demonstrated that decided economies are following the adoption of electrical working. Most railway engineers are aware that the St. Clair tunnel service is the heaviest in the world to which electric traction has been applied. The length of the tunnel itself is nearly 1¼ miles, and with approaches the work has a length of 2¾ miles. When steam working was in operation the limit of the train load was 760 tons, which could only be hauled at low speed on the up-grade, with the result that the capacity of the tunnel, which is single-tracked with double-track approaches, was often taxed to its utmost limits. The electric locomotives were designed to meet the requirements of hauling a 1,000-ton train at a maximum speed of 25 miles per hour, and a minimum of 10 miles, on a gradient of 1 in 10. These conditions have been met, and the traffic capacity of the tunnel should be considerably increased as the result of the electrical working.

For centuries the only property made use of to effect the separation of minerals was the difference in their densities; in 1858, however, an entirely new property was brought into play for the purpose, namely, the difference in their magnetic susceptibilities. This idea was due to a famous Italian engineer, Sella, whose name is well known in connection with the Mont Cenis tunnel. He was called upon to treat the iron ores of Traversella, in Piedmont, which consist of magnetite containing a certain proportion of copper pyrites (the mass carrying 2 per cent to 4 per cent of copper), which interfered with the use of the ore for iron smelting. Sella devised a machine carrying rotating electromagnets, by which the magnetic iron ore was separated from the non-magnetic copper ore, so that both could be utilized. Other machines on similar principles were subsequently devised, and, naturally enough, they emanated from countries rich in deposits of magnetite, such as Scandinavia and some of the eastern States of America. Sweden especially took a prominent part in the development of the magnetic system of separation, and the Wenström machine, patented in 1884, which was one of the first practical machines brought out, is still largely used, as it is well adapted to the separation of lump ore. Other machines, more particularly designed for the treatment of finely crushed ore, were brought out in rapid succession, and to-day one of the main difficulties that beset the mining engineer lies in the selection of the most suitable machine for any given purpose out of the vast number with which the market is flooded. All these machines work either by means of a moving magnetic field, produced by traveling pole-pieces, passing through the mass of crushed ore, or by causing a stream of the ore to traverse a stationary field, these results being obtained either by traveling belts or revolving drums, or, as in the case of Edison's machine, by the deflection of a falling stream. It soon became apparent that, where very clean concentrates were required, the best results could only be obtained by applying magnetic separation to a pulp of mineral suspended in water, and wet magnetic separators were soon introduced, and are to-day preferred wherever possible; they avoid the necessity for artificial drying, which is, moreover, in the case of minerals that contain iron pyrites, apt to affect the magnetic susceptibility of this mineral sufficiently to interfere seriously with the success of the operation. Attempts have been made to devise magnetic separators without moving parts, by the use of polyphase rotating fields, but although the idea looks promising, no satisfactory machine on this principle has yet been constructed.

ENGINEERING NOTES.

Two Hungarians, Herr Christian Berger and Dr. Eugen Klupathy, a professor at the Budapest Polytechnic, have, it is stated, completed an interesting invention with respect to dirigible torpedoes, and Prof. Klupathy recently gave a demonstration of the invention. The torpedo contains machinery by which its course may be directed toward an enemy's ship and automatically altered when the vessel changes its course. In the demonstration by the inventor wireless telegraphy was employed, and the model used altered its direction left or right, according to the will of the operator.

The water-resisting properties of hydraulic cement can be tested by the following comparatively rapid method: Form a cubical block, about two inches in diameter, of the cement, and before it has set, immerse it in water, preferably sea water. Change the water occasionally and, after three months' immersion, take out the block and chip off 1/10 inch or more from each face, so as to leave a rectangular block measuring an inch or less every way, with smooth faces and sharp edges. Immerse this block in a ½ per cent solution of magnesium sulphate in a tightly closed vessel. Renew the solution frequently, carefully examine the block at definite intervals and note the changes it has undergone.

The name magnalium is given to an alloy of magnesium and aluminium, in which the proportion of magnesium varies from 2 to 10 per cent. The alloy, which has been produced in Germany for several years, has now become sufficiently cheap (in consequence of improvements in the production of aluminium) to permit its application to new and interesting uses. Magnalium is even lighter than aluminium, its density being 2.5, while that of aluminium is 2.64. It is capable of receiving and retaining a high polish and is easily cast, rolled, forged, and soldered. Its tensile strength ranges from 20,000 pounds per square inch for cast bars to 71,000 pounds per square inch for drawn wire. For casting, only a very small percentage of magnesium is added, while 6 per cent of magnesium is added for rolled plates, and 10 per cent for tubes.

There is no doubt, states a consular report, that the numerous projects for the construction of railways in Switzerland which will only serve local or, at the most, cantonal interests are filling the minds of the more thoughtful Swiss with apprehension, particularly as the Swiss State Railways are at the present time not showing a working profit, and in all probability will not do so for some time to come. Some of the most important new lines, which are as yet only projected or in course of construction—as, for instance, the Loetschberg tunnel—will only make the present competition more keen, and reduce the receipts of the Swiss State Railways. Among the projects for new railways, a third big line through the Alps has been planned by the inhabitants of the cantons served by the Swiss South-Eastern Railway, the suggested route being either *via* the Splügen, with a direct tunnel underneath the pass of that name, or an ordinary gage line connecting the canton of Grisons with the St. Gotthard line through the Greina Pass. The state of public opinion, however, as well as the tightness of the money market, stands in the way—one might perhaps say, fortunately—of a speedy realization of what are regarded as more or less venturesome projects.

The common practice of anchoring machines by means of iron clamps and screws and massive foundations of masonry or concrete is attended with great expense and serious inconveniences. In order to prevent the clamps and screws from being loosened by the vibration of heavy machines it is necessary to sink them deep in the earth and consequently to employ very heavy foundations, which transmit the vibrations to the ground and the building, to the injury of the latter, the annoyance of neighbors and the depreciation of property in the vicinity. All of these evils, it is claimed, can be avoided by abolishing all clamps, screws, and massive foundations, and simply setting the machine, without fastening it in any way, upon a plate of India rubber laid on the ground. This exceedingly simple foundation very effectively damps the vibrations and holds the machine accurately to its place. The rubber plate makes perfect contact with the ground and with the base of the machine and excludes all air, so that the atmospheric pressure is added to the force of adhesion, and the surfaces of the iron base, the rubber plate and the ground are pressed very firmly together. The familiar experiment with two superimposed plates of glass gives an indication of the great force which is required to separate surfaces thus united. This force increases with the size of the plate and will very rarely be exerted by the vibration of the machine if the plate is sufficiently large. This vacuum foundation method, as it is called, was invented and patented by Baron von Ruegen, and is being operated by a Berlin company. It has been applied, with great success, to many large steam engines and other heavy machines.

TRADE NOTES AND FORMULÆ.

Carbon Safety Ink.—This ink is really no more than a sort of India ink kept in solution. It may be made by rubbing down 10 parts of lampblack, 10 parts of gum, 5 parts of oxalic acid, and 200 parts of water, taking at first but little water and only adding the remainder after the thick mass has become uniform.

Decreasing the Brittleness of Rubber Articles.—This is accomplished by occasional immersion in a 3 per cent solution of carbolic acid. It has also been suggested to preserve rubber articles by placing them in a 1 per cent formaline solution, in a 1 per cent chloride of zinc solution, or in a concentrated solution of boracic acid.

Cement for Gas Retorts.—A cement that is always handy is obtained by mixing suitable lean clay, china clay for instance, with a solution of caustic soda. A concentrated soda solution may also be used. Either an addition of 10 per cent of caustic soda or 20 per cent calcined soda to the clay, is required. The addition of alkali is, of course, governed by the fire-resistant property of the available clay.

Carmine.—According to Ceuette's method, over 1,000 parts of prime pulverized cochineal, 75,000 parts of boiling distilled water are poured and boiled for 2 hours, then 25 parts of pure saltpeter added and after 3 minutes, 30 parts of bioxalate of potassium (oxalium); boil 10 minutes longer, then allow it to stand for four hours, the fluid after settling being transferred to large glass dishes, in which it remains three weeks. After this period, the mould is removed, the fluid drawn off by means of a pipette and the carmine deposit dried in the shade. According to another process, soda or potash and subsequently alum, are admixed to the cochineal and the separation of the carmine effected by means of white of egg or isinglass. Carmine containing albumen is very difficult to pulverize, whereas that obtained with the help of isinglass is very friable.

Paper Saws.—It is probably well known to our readers that by means of revolving soft copper disks the edges of which are served with diamond dust by beating it in, diamonds can be sawed up. By means of sharp, rapidly-revolving iron disks it is possible to cut through heavy steel armor plates, of 4 to 8 inches in thickness. These phenomena belong to a very interesting department in physics, the physics of revolving bodies, that doubtless still has a great deal that is remarkable to offer. The rotation of a wheel results in the phenomenon that keeps the wheelman or bicyclist, without exertion, free on his seat, i. e., the so-called free axis. We can also observe it easily in a top, which, its equilibrium disturbed, as long as the rotation is rapid enough, always resumes a certain position in regard to its axis, without requiring pivot bearings. Rotation also exercises a tension-producing effect on the substance of a revolving body and it is this tension that imparts to the soft saws referred to their notable efficiency. If, for instance, a disk of thin cardboard is caused, by a suitable transmission, to rotate very rapidly on the lathe, the rotatory tension causes the card to behave like sheet metal. As the Naturwissenschaftliche Wochenschrift states, the cardboard can, in such case, no longer be bent and if struck with a hammer, gives off a sound as though we were striking bronze. This is, however, only the beginning. If we place on the shaft of an electro-motor a disk of good paper, cut into an exact circle of about 8 inches diameter, this paper disk can be made at the highest rotating speed of the motor to saw through cigar-box wood. At the cutting surface it acquires a fine brown polish. The publication in question, in a recent issue, shows other interesting experiments. We can, for instance, fit on the shaft of the rotatory apparatus a drum, about which may be passed an annular closed little chain in such a manner, that, at the highest rotatory speed of which the motor is capable, it can be slipped off the drum. The chain will then behave like a solid ring, roll across the table, and when it strikes the ground bounce up like a hoop. The active principle on which all these tension phenomena are based is centrifugal force.

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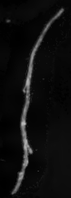
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